

**TREATABILITY STUDY WORKPLAN
INTRINSIC SEDIMENT PROCESSES STUDY
SITES 2 AND 17
NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA
FINAL**

CONTRACT NO. N62474-94-D-7430
Delivery Order No. 004

Submitted to:

Department of the Navy
Engineering Field Activity, West
Naval Facilities Engineering Command
900 Commodore Drive
San Bruno, California 94066-5006

Submitted by:

Berkeley Environmental Restoration Center
461 Evans Hall
University of California
Berkeley, CA 94720-1706

Revision 1

February 1997

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ALAMEDA, CALIFORNIA
(DRAFT FINAL)**

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1.0 INTRODUCTION

This Work Plan describes an Intrinsic Sediment Processes Study for the Naval Air Station (NAS) Alameda to be conducted by the University of California at Berkeley (UCB). A major focus of the studies will be to evaluate whether intrinsic processes (those that occur in the natural, undisturbed sediment systems) are transforming or immobilizing chemicals released by past operations into sediments at two locations at NAS Alameda. These locations are referred to as Site 17, the Seaplane Lagoon, and the wetlands portion of Site 2, the West Beach Landfill.

The management of sediments containing chemicals is one of the most complex and challenging tasks facing the remediation community in the United States and the U.S. Navy (Navy) at NAS Alameda. UCB, the Lawrence Livermore National Laboratory (LLNL), and the Lawrence Berkeley National Laboratory (LBNL) have combined their expertise and resources to form the Berkeley Environmental Restoration Center (BERC) to demonstrate and apply innovative approaches to the solution of difficult environmental problems, such as the management of contaminated sediments.

BERC has assembled a team that includes recognized experts in ecotoxicology, sediment and chemical transport mechanisms, chemical characterization and transformation, and subsurface characterization to evaluate the processes occurring in sediments at NAS Alameda. Resumes of BERC Investigators are included in Appendix A. This evaluation will provide the Navy, the environmental regulatory agencies, and the Alameda community with information regarding sediment conditions in the Seaplane Lagoon and the West Beach Landfill Wetlands that may require active remediation and the chemicals within those sediments that are of concern. The study will also develop information used to specify the design basis for selected active remedial alternatives, such as capping of sediments, dredging of sediments, or modification of wetlands drainage.

1.1 DESCRIPTION OF INTRINSIC SEDIMENT PROCESSES

The study described in this Work Plan will evaluate the intrinsic processes that may be incorporated into remedial approach(es) for chemicals of concern within the sediments found in the Seaplane Lagoon and the West Beach Landfill Wetland. The results will be used by the Navy in a future engineering evaluation and cost analysis or feasibility study to develop general clean-up response actions for the Seaplane Lagoon and the West Beach Landfill Wetland. The results may also be used as a design basis for other remedial alternatives, such as capping.

A number of chemicals used in past operations at NAS Alameda have been transported through the storm drains into the sediments within the Seaplane Lagoon. Some of the chemicals disposed in the West Beach Landfill, most notably several classes of nonvolatile organic chemicals, apparently have migrated into the West Beach Landfill Wetlands through runoff and erosion from the landfill. These chemicals may also have been present on the soils/sediments used as fill in the area that now constitutes the wetlands site. These chemicals are either bound to the sediment by sorption processes or present as an organic liquid if they were released as free product (oils, solvents, etc.). Whether the chemicals are bound to sediments or are present as a free-phase liquid, the sediments may serve as a continuing source of chemicals to the bay and lagoon and their ecosystems for many decades.

The chemicals within the sediments may reach humans and animals via several pathways. Because the chemicals are now associated with sediments in the lagoon and wetlands, direct human exposure by dermal, inhalation or ingestion routes is not expected to be significant. Predominant exposures are expected to be flora and fauna that contact the sediments. These exposures may be

accelerated by sediment disturbance, including dredging, that may be necessary for sediment remediation or for improving the recreational or ecological value of the sites.

While dredging may accelerate release of chemicals, other processes are effecting sediments. Processes that occur in the natural, undisturbed sediment system are referred to as "intrinsic" processes. Intrinsic processes are of particular interest because they may effectively reduce the concentrations of chemicals in the environment or decrease their ability to exhibit toxic effects without invasive remedial site activities. The Intrinsic Sediment Processes Study will also estimate the rates at which these chemicals are likely to move from the sediments into surrounding waters under disturbed conditions. The study will characterize the following conditions and intrinsic processes:

- (1) toxicity and bioavailability of chemicals within the sediments under existing conditions
- (2) geochemical transformations within the sediments
- (3) biological transformations within the sediments
- (4) chemical transport out of the sediments
- (5) toxicity and bioavailability of chemicals that have been released from the sediments.

1.2 PARTNERSHIP AGREEMENT

On August 24, 1994, the Navy and UCB entered into a formal partnership that provides the framework for exploring the application of innovative environmental restoration technologies developed by UCB, LLNL, and LBNL to Installation Restoration (IR) sites at NAS Alameda. As part of the partnership agreement, UCB established the Berkeley Environmental Restoration Center (BERC) as a coordination office to administer the contract for UCB. The partnership is governed by Contract No. N62474-94-7430.

Delivery Order (DO) 4 of the contract authorizes limited sampling and specialized analysis of the sediments of the Seaplane Lagoon and the West Beach Landfill Wetlands. Specific tasks that are authorized include:

- (1) preparation of a coordinated sampling and analysis plan
- (2) implementation of the coordinated sampling and analysis plan
- (3) preparation of a sampling and analysis report
- (4) participation at project meetings.

Originally, DO 4 was to include only the Seaplane Lagoon. In late 1995, the Navy and UCB agreed to include the West Beach Landfill Wetlands in the Scope of Work. After the additional site was added, the scope of work was reduced to evaluate only intrinsic processes that occur in sediments. Studies to assess enhanced remediation of sediments may be performed as part of future delivery orders.

This work plan was written by UCB to fulfill the requirements of Task 1 and describes the investigation that will be implemented to fulfill the requirements of Task 2. At the completion of the Intrinsic Sediment Processes Study, UCB will prepare a report to fulfill the requirements of Task 3. UCB, LLNL, LBNL, and subcontractor personnel are available for meetings to fulfill the requirements of Task 4.

During implementation of the Intrinsic Sediment Processes Study, LBNL will be responsible for conducting:

- Pore water toxicity testing
- Stable isotope ratio monitoring
- Organic chemical analyses

LLNL will be responsible for conducting the following assays:

- Toxicity identification evaluations
- ¹⁴C radio-isotope tracking
- Chemical characterization of metal speciation
- Geochemical analyses

UCB will be responsible for:

- Project oversight and coordination
- Acoustic imaging of sediments
- Assessment of transport and transformation rates
- Bioavailability assays
- Microbial transformation studies of selected chemicals of concern

1.3 INTRINSIC SEDIMENT PROCESSES STUDY DECISION PROCESS

An evaluation of the initial site characterization data for the Seaplane Lagoon and the West Beach Landfill Wetlands (summarized in Section 2) indicated that intrinsic remedial processes are appropriate remedial alternatives to consider for some of the sediments at these sites. The concentrations of chemicals, especially organic chemicals, in some of the sediments may be sufficiently low that concentrations will decrease due to natural transformation processes. Additionally, metals in sediments may be sorbed or present in a solid phase that precludes their transport out of sediment.

As mentioned at the beginning of this section, the evaluation of sediment remediation options is a complex process involving many disciplines. Decisions regarding the scope of the study centered on two major issues:

- Allocation of effort between the Seaplane Lagoon and the West Beach Landfill Wetlands,
- Inclusion of petroleum hydrocarbons, particularly polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in the studies.

Petroleum hydrocarbons have been included in the proposed study because they influence the rates of transformation of chemicals and they influence the mobility of both metals and other organic chemicals. Metals are a focus of some studies because they have been observed at potentially toxic concentrations in several sediment samples, and their chemistry is an indicator of conditions influencing transformation of organic chemicals. PAHs and PCBs in particular have been identified as potential chemical classes of concern, and have been included in the studies for this project.

The general decision process for the implementation of this Intrinsic Sediment Processes Study is diagrammed on Figure 1-1. This draft work plan will be reviewed by the Navy, the environmental regulatory agencies, the Restoration Advisory Board (RAB), and the Base Realignment and Closure (BRAC) Closure Team (BCT). After these reviews, the Navy will authorize preparation of the final work plan. After considering reviews of the Final Work Plan, the Navy will authorize

implementation of the Intrinsic Sediment Processes Study. Individual tasks in the Work Plan, such as acoustic imaging, may be authorized earlier based on technical memoranda submitted by BERC and the need for such studies to begin earlier.

Technical reports for the individual discipline studies will be prepared soon after the data analyses for the respective studies are completed. With the Navy's concurrence, these reports will be peer reviewed, revised, and submitted to the Navy as interim reports. These reports will then be included as appendices for a draft final report for the Intrinsic Sediment Processes Study, which will be reviewed by the Navy, regulatory agencies, the RAB, and the BCT. The final report may be utilized by the Navy and their feasibility study contractor in either an engineering evaluation and cost analysis for an earlier clean-up response such as removal or an interim remedial action, or a feasibility study for a final remedial action.

1.4 SCOPE OF PROPOSED STUDIES

The studies to be conducted by BERC are primarily intended to provide data to be used in the context of a feasibility study that will be prepared by the Navy's contractor, PRC. Some studies will provide information on baseline conditions against which consequences of remedial options can be compared, and PRC may also use these data in ecological assessments if the data are of the appropriate quality (that is detection limits, analytes and methods are comparable to PRC data). Remedial alternatives that may be considered in the feasibility study include leaving sediments in place, or the partial removal of sediments. Active remediation options such as capping of sediments in place or in-situ treatment of sediments have also been suggested, and the disturbance of sediments during active remediation and the related short-term exposure pathways during remediation are of concern.

The studies conducted by BERC are not intended to completely define any of the remedial alternatives, but rather are planned as innovative approaches on a limited number of samples to provide an additional level of understanding regarding the intrinsic processes and conditions, and to address some aspects of selected remedial alternatives. This information will be used for the evaluation and selection of the remedial actions under consideration by the Navy. BERC investigators will contribute to those evaluations by the Navy and its contractors as requested. For this contract, innovative methods are those procedures and measurements that are not in routine use nor available from commercial laboratories, and which can be implemented using the expertise and sometimes unique facilities available at the University of California at Berkeley (UCB), Lawrence Berkeley National Laboratory (LBNL), and Lawrence Livermore National Laboratory (LLNL)

In the planning of data collection and uses, it must be recognized that including intrinsic processes as a part of a feasibility study/remedial action selection for sediments requires a somewhat different approach compared to the use of active remediation measures. The most critical differences are that the intrinsic (natural and/or undisturbed) processes are usually less buffered, more spatially variable, and less certainly defined than when active (or externally-induced) measures are applied; the time scale for the intrinsic process is also often longer than for active remediation. Therefore, complementary and sometimes overlapping lines of evidence are important to conclusively demonstrate that the intrinsic processes are occurring and to determine the rate-limiting processes. Such demonstrations usually require monitoring of several site-specific parameters and conditions that are used in the context of conceptual and mathematical models, and which together support the conclusion that the natural (intrinsic) processes are occurring. While such activities might otherwise be regarded as a characterization effort, they have direct relevance to the issues of treatability of the sediments, or the consequences of imposing certain sediment management techniques. The evaluation of intrinsic processes as part of a remedial plan are then distinct from active remediation processes where external sources are used to enhance or overwhelm a natural condition, and where responses to the changed condition can be unambiguously determined (for example, a proportional chemical concentration decrease in response to applied enhancement.).

1.5 RELATED DOCUMENTS

BERC has developed program level documents that describe procedures to be followed on projects implemented under the partnership agreement. These include:

- The BERC Quality Control Program Plan
- The Health and Safety Plan (Program), Volumes I and II;
- Standard Operating Procedures (SOPs)
- Standard Quality Procedures (SQPs).

Work at the Seaplane Lagoon, the West Beach Landfill Wetlands, and commercial and BERC laboratories will be conducted in accordance with the general procedures described in these program level documents and as more specifically described in this Work Plan. Applicable SOPs and SQPs for this project are identified in Table 1-1 (Applicable Standard Operating Procedures and Standard Quality Procedures). The program level documents are updated periodically and the most recent version of each document is maintained in the BERC office.

1.6 ORGANIZATION OF WORK PLAN

Section 1 of this Work Plan presents the background and objectives of the Intrinsic Sediment Processes Study for the Seaplane Lagoon and the West Beach Landfill Wetlands, as well as the contracting mechanisms that authorize the work and program level documents guiding the study. A history of operations at NAS Alameda as well as the Seaplane Lagoon and West Beach Landfill area is presented in Section 2 with a discussion of previous investigations, site hydrogeology, soil and groundwater quality, and probable exposure pathways. Section 3 provides an overview of the conceptual approach of the Intrinsic Sediment Processes Study and summarizes the information that will be developed by UCB, LLNL, and LBNL. The Sampling Approach, detailing the field activities to be conducted, is presented in Section 4. The Methods and Analyses is contained in Section 5. Integration of the data into a description of transport and fate under intrinsic conditions is the subject of Section 6. The Quality Assurance Project Plan is included as Section 7. Reporting is described in Section 8. Project Management is described in Section 9. Because of the breadth of studies to be conducted, pertinent references are cited in Section 2 (History of Operations) and Section 5 (Methods and Analyses) under the respective studies to facilitate locating the referenced material.

Appendix A contains resumes of Intrinsic Sediment Processes Study personnel. Appendix B contains the Sampling and Analysis Plan, including project specific procedures and SOPs that have been developed for the study. These procedures and SOPs supplement the program level SOPs (BERC, 1996b). The Site Specific Health and Safety Plan for field work related to the study is included as Appendix C.

**TABLES
&
FIGURES**

Table 1-1
Applicable Standard Operating Procedures and Standard Quality Procedures

Title	Number
STANDARD OPERATING PROCEDURES	
Chain of Custody	1.1
Sample Handling, Packaging and Shipping	2.1
Subsurface and Shallow Subsurface Soil Sampling	3.1
Drilling and Heavy Equipment Decontamination	6.2
Sample Labeling	17.1
Sample Numbering	17.2
Isotope Monitoring	24.4
Sediment Coring Procedures	25.1
Sediment Sampling for Pore Water Extraction	25.2
Pore Water Isolation	25.3
Acoustic Imaging of Sediments	25.4
Microelectrode Measurements in Sediment Core Pore Waters	26.1
Pore Water Constituent Measurements	26.2
Sediment Bulk and Mineralogical Analyses	26.3
Sediment Metal Speciation Analyses	26.4
Leaching from Disturbed Sediments	26.5
Pore Water Toxicity Test	27.1
Sediment Water Interface Core Test (SWIC)	27.2
Toxicity Identification Evaluations	27.3
Acid Volatile Sulfides and Simultaneously Extracted Metals	27.4
Bioavailability/Bioaccumulation by the Bivalve	28.1
Digestive Fluid Extraction	28.2
Lead-210 Profile in Sediment	29.1
Measurement of Lagoon Sediment Properties	29.2
Fingerprinting PAHs, PCBs, Hydrocarbons and Hydrocarbon Tracers	30.1
Intrinsic Production of Methane in Anaerobic Lagoon Sediments	30.2
Intrinsic Transformation of PAHs and PCBs in Anaerobic Sediments	30.3
Constraints on Transformation of PAHs and PCBs in Sediments	30.4
Transformation of PAHs and PCBs in Vadose Zone Soil Plots	30.5

Table 1-1 (Continued)
Applicable Standard Operating Procedures and Standard Quality Procedures

Title	Number
STANDARD QUALITY PROCEDURES	
Project Self Assessment	3.1
Indoctrination and Training	3.2
Document Control	4.1
Records Management	4.2
Preparation, Revision and Approval of Plans and Procedures	5.1
Preparation, Review, and Approval of Procurement Documents	6.1
Calibration and Maintenance of Measuring and Test Equipment	8.2
Control of Tests	9.1
Nonconformance Control	10.1
Corrective Action	10.2
Stop Work Order	10.3
Field Work Variance/Request for Information	11.1
Quality Audits	12.1
Quality Surveillances	12.3

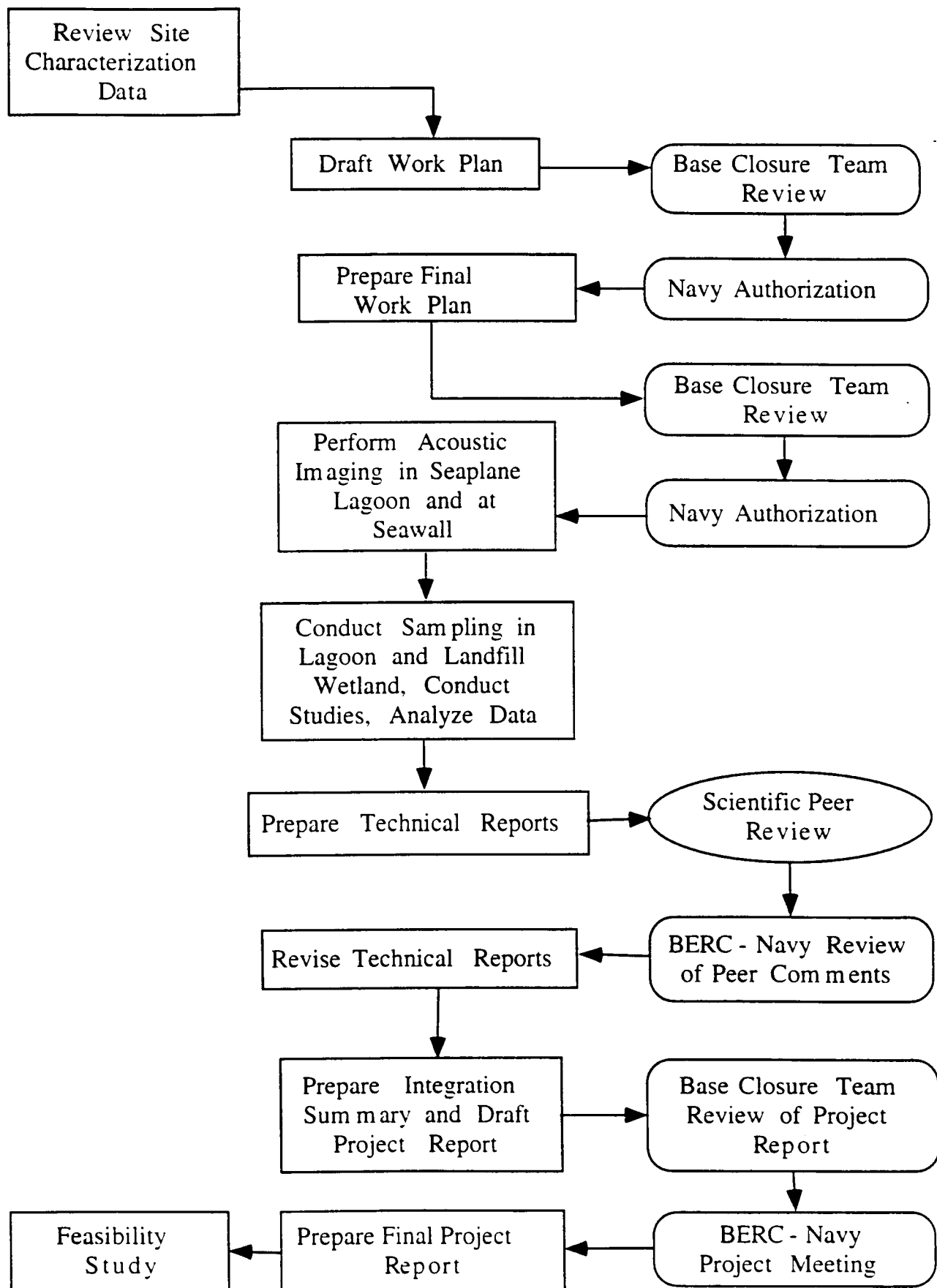


Figure 1-1. Study Decision Process for Sites 2 and 17

2.0 HISTORY OF OPERATION

2.1 INSTALLATION DESCRIPTION

NAS Alameda (Figure 2-1) lies on the western end of Alameda Island, in Alameda and San Francisco Counties. Alameda Island lies in the eastern San Francisco Bay, adjacent to the city of Oakland. Rectangular in shape, NAS Alameda is approximately 2 miles long and 1 mile wide, and occupies 2,634 acres, of which 1,108 acres are submerged.

At least two large industrial sites, a borax processing plant and an oil refinery, were located on the island near what is now NAS Alameda prior to 1930. The U.S. Army acquired the NAS site from the city of Alameda in 1930 and began construction in 1931. In 1936, the Navy acquired title to the land from the Army and began building the air station in response to the military buildup in Europe prior to World War II. The station is largely constructed on hydraulic fill material. After the 1941 entry of the U.S. into the war, more land was acquired adjacent to the air station. Following the end of the war, NAS Alameda returned to its original primary mission of providing facilities and support for fleet aviation activities.

Currently, the eastern portion of the station is developed with offices, residences, and industrial facilities. The western portion of the station is primarily developed with runways and support facilities.

2.1.1 Basewide Geology

This section summarizes the geology and hydrogeology of NAS Alameda from the *Remedial Investigation/Feasibility Study Final Aquifer Test Work Plan* prepared by PRC and Montgomery Watson (MW). The summary is based on previous remedial investigations performed at NAS Alameda since 1990.

Alameda Island is underlain by approximately 400 to 500 feet of unconsolidated sediments overlying consolidated Franciscan bedrock. The uppermost unconsolidated units at NAS Alameda are described below. The unconsolidated units, from youngest to oldest, are:

- artificial fill;
- Holocene Bay Mud;
- late Pleistocene/Holocene deposits (Posey Formation, late San Antonio Formation, and Merritt Sand); and
- late Pleistocene estuarine deposits (San Antonio Formation).

Figure 2-2 presents an idealized stratigraphic column showing these units. The generalized stratigraphic relationship of these units is illustrated on Figure 2-3.

Artificial Fill. Artificial fill is the shallowest unit identified at NAS Alameda. The thickness ranges from 0 to 40 feet; the range of thickness is a result of natural variation in the depth of the estuary prior to filling, which began in the late 1800s. This unit is thinnest or absent beneath the easternmost portion of the air station which was a tidal flat in 1856 (Figure 2-4). Artificial fill reaches the greatest thickness in the western part of NAS Alameda.

The artificial fill consists of hydraulically placed dredge spoils from the surrounding San Francisco Bay, Seaplane Lagoon, and the Oakland Channel. The composition of the artificial fill varies, but

generally consists of silty sand to sand with minor inclusions of clay and gravel. The artificial fill composed of sand is similar in texture to the underlying late Pleistocene/Holocene eolian deposits, which in most cases served as a source for the artificial fill where it underlies the surrounding San Francisco Bay.

Little information on the timing of the artificial fill operations is available. Historical aerial photographs indicate that fill was placed in east-west linear rows with the intervening swales filled with water. This filling procedure may have produced a systematic variation in grain size of the fill material, with finer-grained material being deposited closer to the water-filled swales and coarser-grained material being deposited closer to the point at which the hydraulic pipe discharged. This potential variation in grain size, if present, could affect shallow groundwater flow in the first water-bearing zone by creating preferential groundwater flow paths within the coarser-grained material.

Holocene Bay Mud. Holocene Bay Mud is the youngest naturally occurring unit in the vicinity of NAS Alameda; it was deposited in an estuarine environment and is still being deposited in San Francisco Bay. Although commonly referred to as "Bay Mud," the unit locally contains substantial amounts of sand. In some areas of the western portions of NAS Alameda, this unit is composed predominantly of sand. Bivalves are present in some portions of the unit. In the eastern portion of NAS Alameda, the uppermost portions of the Holocene Bay Mud contain abundant plant remains. The historical shoreline around 1900 is shown on Figure 2-5.

The Holocene Bay Mud ranges in thickness from approximately 35 feet at the western part of NAS Alameda to 0 feet at the extreme eastern part of San Francisco Bay. The Holocene Bay Mud is encountered at a depth of approximately 25 feet below ground surface (bgs) beneath the western part of NAS Alameda and approximately 5 feet bgs beneath the eastern part of NAS Alameda. The depth to the top of the Holocene Bay Mud reflects the approximate water depth in the bay, prior to artificial fill operations.

Late Pleistocene/Holocene Deposits. Alluvial and eolian deposits of late Pleistocene to Holocene age unconformably overlie the late Pleistocene estuarine deposits (described below). Eolian deposits which include Merritt Sand, form a major water-bearing zone under the Seaplane Lagoon. The alluvial deposits have partially filled preexisting valleys that were 150 feet or more deep and up to 1,000 feet wide. They also blanket adjacent flat lands. The thickness of the alluvial deposits is reported to range from 10 to 40 feet in the eastern portion of NAS Alameda and 7 to at least 72 feet in the central portion of NAS Alameda. The unit consists of medium grained sand containing varying amounts of silt and clay that may have been deposited in a deltaic environment.

The eolian deposits formed as sand dunes when sea level was much lower and the shoreline was located outside the Golden Gate passage on what is the present continental shelf. The thickness of the eolian deposits is 8.5 to 56 feet beneath the eastern portion of NAS Alameda, 19 to 60 feet beneath the central portion, and 9.5 to 48 feet beneath the western portion. The eolian deposits are present at a depth of approximately 45 feet bgs at the western part of NAS Alameda and occur at approximately ground level at the eastern part of NAS Alameda. In the vicinity of NAS Alameda these deposits consist of fine-grained sand to silty sand. Bivalve shells and shell hash are observed in parts of the unit. An east-west trending paleochannel has previously been identified that downcut into and removed the alluvial and eolian deposits from the central part of NAS Alameda. Within the paleochannel, the Holocene Bay Mud directly overlies late Pleistocene estuarine deposits.

Late Pleistocene Estuarine Deposits. The estuarine deposits in the vicinity of NAS Alameda consist of a dark greenish-gray silty clay, and are approximately 140 feet thick under the westernmost portion of Alameda Island. The unit is considered an aquitard and is present at a depth of approximately 90 feet under the westernmost portions of NAS Alameda.

2.1.2 Basewide Hydrogeology

The sediments beneath NAS Alameda are subdivided into two aquifers. The shallow, or first, aquifer consists of two water-bearing zones (Figure 2-3). The first water-bearing zone of the first aquifer is in the artificial fill and continues partially into the Holocene Bay Mud where this unit consists of more permeable sand. The second water-bearing zone of the first aquifer is in the late Pleistocene/Holocene alluvial and eolian deposits including the Merritt Sands. A deeper, or second, aquifer is in the underlying undivided Pliocene/Pleistocene terrestrial deposits (not described in this Work Plan); this aquifer is not of interest in this study. It is separated from the first aquifer by late Pleistocene estuarine deposits, which form an aquitard.

Previous investigations considered the first and second water bearing zones of the first aquifer to be separated by the Holocene Bay Mud (PRC and MW, 1995). However, the Holocene Bay Mud has been found to be discontinuous beneath several areas, especially the southeastern part of NAS Alameda. Thus, in these localized areas, the first and second waterbearing zones of the first aquifer are considered to be in partial hydraulic connection (PRC, 1991). Because of this, the uppermost waterbearing zone in the eastern portions of NAS Alameda includes the late Pleistocene/Holocene-age alluvial and eolian deposits. The extent and depth of Bay Mud under the Seaplane Lagoon and West Beach Landfill Wetland is not known.

Groundwater in the first water-bearing zone is unconfined and is first encountered at approximately 3 to 5 feet bgs throughout most of NAS Alameda. Groundwater in the second water-bearing zone (including Merritt Sand) is semiconfined beneath much of NAS Alameda. In the eastern areas of the base, where the Holocene Bay Mud is absent, the second water-bearing zone merges with the first and groundwater occurs under unconfined conditions. Where the Holocene Bay Mud is present, the water pressure or head in the second water-bearing zone generally rises to the same level as in the first water-bearing zone.

2.2 SEAPLANE LAGOON, SITE 17

2.2.1 Site Description and History

The Seaplane Lagoon (Site 17) is located at the southeastern corner of NAS Alameda (Figure 2-1). The site consists of a body of water with a surface area of 110 acres; it is 12 to 17 feet in depth and is almost entirely surrounded by seawalls (Figure 2-6). The entrance to the lagoon from San Francisco Bay is through an approximately 800 foot opening in the southwestern end of breakwater extending from Pier 1. The opening allows tidal circulation to occur. Outside the lagoon are berths for deep draft ships (Piers 1, 2, and 3, Figure 2-6). The berths are protected by an outer breakwater (PRC, 1994a). There is no information on the depths of the sediment and Bay Mud within the lagoon itself, or on water transport between overlying water, sediment and lower strata.

From 1943 to 1975, the lagoon served as a receiving basin for an estimated 300 million gallons of wastewater from the combined storm and sanitary sewer system. This system received wastewater from many industrial operations throughout NAS Alameda and discharged to seven outfalls within the Seaplane Lagoon; the outfall locations are shown on Figure 2-6 by the letters A through G. Since 1975, when industrial wastewater was first segregated, the lagoon has received only storm sewer discharge and surface runoff (PRC, 1994a).

Wastewater discharged to the Seaplane Lagoon prior to 1975 was reported to contain metals, solvents, paints, detergents, acids, caustics, mercury, oil and grease, and PCBs. Ships docked at the piers south of the entrance to the Seaplane Lagoon discharged wastewater containing solvents, chromium, waste oil, and fuel which could have been swept into the lagoon by tidal action. During

the 1960s and 1970s, antifouling paint was used on the bottom of small boats; this is another potential source of metals to the Seaplane Lagoon.

2.2.2 Potential Sources of Chemicals

The potential sources of chemicals in and adjacent to the Seaplane Lagoon include other Navy Installation Restoration Program (IRP) sites such as the Navy hazardous waste clean-up program sites at NAS Alameda which discharged to the Seaplane Lagoon through the combined storm and sanitary sewer system prior to 1975, adjacent IRP sites, and present day vessel and seaplane operations in the areas adjacent to the lagoon (PRC, 1994a). These IRP sites (Figure 2-1) are not expected currently to be discharging to the Seaplane Lagoon, but are described below to illustrate the complex nature of the past releases of chemicals to the Seaplane Lagoon. Operations at these IRP sites are summarized in Table 2-1 and are discussed below.

IRP Site 6: Building 41. Building 41 at Site 6 (Figure 2-1) is one of several hangars located along the northern boundary of the Seaplane Lagoon. This building was formerly used as a hangar for seaplanes, but is now occupied by the Aircraft Intermediate Maintenance Department (AIMD). A storm drain located near the paint stripping and hazardous waste drum storage area discharges into the Seaplane Lagoon and may have been a source of chemicals to the lagoon. Chemicals stored and used in the building include a petroleum hydrocarbon solvent (PD680), dry cleaner solvents, hydraulic oil, paint wastes, and used hydraulic fluids.

IRP Site 8: Building 114 Pest Control Area. Building 114 at Site 8 (Figure 2-1) now serves as an administrative center and as a location for Public Works Center (PWC) activities including maintenance painting. The building formerly housed a woodworking shop, steam cleaning shop, and a storage facility for pesticides and herbicides. Steam cleaning, paint stripping, and spray painting generated approximately 264 gallons of wastewater per day, which were discharged directly into storm drains. The storm drains emptied into the Seaplane Lagoon. Separator pits functioned inadequately, and their contents were routinely dumped at the West Beach Landfill.

Prior to 1974, the facility stored pesticides and herbicides. Equipment used in weed and pest control was likely rinsed at this site and the rinsate may have been discharged to the lagoon. The pesticides and herbicides stored at the site included chlordane, lindane, DDT, malathion, diazinon, Telvar, Chlorvar, 2,4-D, Roundup, Princep, and Krovar 1.

IRP Site 10: Building 400 Missile Rework Facility. Building 400 at Site 10 (Figure 2-1) is at the northwest corner of the Seaplane Lagoon and houses a small paint shop and cleaning shop. Prior to 1972, the building housed the missile rework operations. Wastes generated included sludge, metal shavings, paint strippers, cleaning solvents, and oil and grease. These wastes were usually deposited in the West Beach Landfill. Wastewater from Building 400 contained solvents, heavy metals, and phenols. This wastewater was discharged, untreated, into the industrial wastewater collection system. It is unknown whether any wastes were discharged to storm sewers that emptied into the Seaplane Lagoon.

IRP Site 11: Building 14 Engine Test Cell. Building 14 Site 11 (Figure 2-1) is east of the Seaplane Lagoon. At present, two engine test shops and several laboratories are housed in this building. The laboratories have had small mercury spills in the past. Waste generated during cleanup of these spills was disposed of in the West Beach Landfill.

IRP Site 18: Station Sewer System. Part of the NAS Alameda storm sewer system discharges directly into the Seaplane Lagoon at seven outfall locations, four of which are at least 0.75 meters in diameter; the outfall locations are shown on Figure 2-6. Until 1975, the system received untreated wastewater from plating bath dumps, paints and paint strippers, pesticides and herbicides, oil and grease, cleaning solvents and, possibly, PCB-contaminated oils. After 1975, all

wastewater was transferred to the industrial wastewater treatment plant. The sewer system is reported to be constructed mainly of corrugated steel pipes which may be in poor condition; if the sewer lines are cracked or leak, contaminants from untreated wastewater could enter the soil or groundwater. The sewers open into the Seaplane Lagoon and at high tide seawater may flow up into the pipes.

2.2.3 Previous Investigations

Investigations were conducted at the Seaplane Lagoon, Site 17, in 1983, 1985, 1987, 1988, 1991, and 1993. The previous investigations were as follows:

- In 1983, Ecology and Environment conducted an initial assessment at NAS Alameda, which included Site 17. The report documenting this assessment was referenced in subsequent reports reviewed by UCB but is not currently available for review.
- In 1985, Wheeler Associates collected eight sediment samples from the bottom of the Seaplane Lagoon and two sediment samples from the channel outside the lagoon. The samples were analyzed for metals, PCBs, and pesticides. No PCBs or pesticides were detected. Metals were detected in both the lagoon and the channel samples. The report concluded that metals concentrations were not sufficiently high to pose an environmental threat. The report documenting this sampling was referenced in subsequent reports reviewed by UCB but is not currently available for review.
- Extensive sediment sampling was conducted by several groups in 1987, 1988, and 1991 to characterize maintenance dredging materials in the outer breakwater area of Piers 1, 2, and 3 adjacent to the Seaplane Lagoon (PRC, 1994). Among the chemicals detected were PCBs (as Aroclor 1016), heptachlor, phthalate esters, sulfides, zinc, lead, anthracene, and organotin. Bioassays were conducted using mussel (*M. edulis*) larvae as the test organism. Four of the test samples showed greater than 50 percent abnormal development at the highest test concentration (100 percent elutriate). The report documenting this sampling was referenced in several reports reviewed by UCB but is not currently available for review.
- In 1993, PRC conducted an environmental assessment that included the Seaplane Lagoon (PRC, 1994a). As part of this assessment, surficial sediment samples were obtained from the 0 to 10 centimeter depth interval at seven locations (S1 through S7); water samples and sediment cores a maximum of 120 cm deep were obtained from three locations (S3, S4, and S7); and storm water samples were obtained from three locations in an industrialized portion of NAS Alameda (SW-1, SW-2, and SW-3). The storm sewer lines sampled drain to the Seaplane Lagoon. Sample locations are shown on Figure 2-6.
- Screening bioassays were conducted on each surficial sediment sample. Bioaccumulation studies and analyses of benthic populations for species diversity were performed for those samples (S2, S3, S5, and S7) that exhibited significant effects in the bioassay testing.

2.2.4 Summary of Analytical Data

The results of the ecological assessment conducted in 1993 (PRC, 1994a) were reviewed to assess the water and sediment quality within the Seaplane Lagoon and identify the distribution of chemicals within the sediments. The review included assessment of the data presented in the report; an independent assessment of the raw data was not conducted. The results of this review have been used in later sections to select appropriate sampling locations for this treatability study.

To simplify the discussion of the data and identify the general distribution of chemicals in the water and sediment, data summary tables provided in this section include the total concentrations of PAHs, PCBs, organochlorine pesticides, and organotins detected in each sample based on the analytical results presented in the report prepared for the ecological assessment (PRC, 1994).

Specific metals are identified where appropriate. Samples were generally analyzed for semivolatile organic compounds (SVOCs), with the primary SVOCs of concern being total PAHs.

2.2.4.1 Water Quality

Lagoon Water Samples. Water samples from sampling locations S3, S4, and S7 (Figure 2-6) were analyzed for SVOCs, organochlorine pesticides, PCBs, total petroleum hydrocarbons (TPH), total and dissolved metals, organotins, chemical oxygen demand, biological oxygen demand, total suspended solids, dissolved organic carbon, total organic carbon, salinity, and dissolved oxygen. Summary analytical results are presented in Table 2-2 and analytical results for the specific metals detected are included in Table 2-3.

Dissolved metals were not identified in any of the water samples. The total metals detected are chromium, lead, and zinc. The TPH concentration detected in these samples ranged from 1.6 milligram per liter (mg/l) in the sample from S3 to 1.8 mg/l in the sample from S7. PAHs, organotins, organochlorine pesticides, and PCBs were not detected in the water samples.

The salinity of each water sample was approximately 26.3 parts per thousand (ppt) and the dissolved oxygen ranged concentration ranged from 7.6 mg/l in the sample from S7 to 9.8 mg/l in the sample from Station S4. The biological oxygen demand of each sample was approximately 2 mg/l. Total suspended solids were identified at approximately 4 mg/l in each water sample. Total organic carbon and dissolved organic carbon were not detected in the water samples.

Storm Water Samples. In 1993, storm water samples from sampling locations SW1, SW2 and SW3 (Figure 2-6) were analyzed for SVOCs, organochlorine pesticides, PCBs, TPH, total and dissolved metals, organotins, chemical oxygen demand, biological oxygen demand, total suspended solids, dissolved organic carbon, and total organic carbon. The pH and dissolved oxygen content of the water were measured in the field. Summary analytical results are presented in Table 2-2 and analytical results for the specific metals detected are included in Table 2-3.

Total metals detected in the samples were cadmium, copper, lead, and zinc. Dissolved metals detected were cadmium, lead, and zinc. The total organotin concentration ranged from not detected in sample SW1 to 103 micrograms per liter (ug/l) in sample SW2; the organotins detected include dibutyltin, tributyltin, and tetrabutyltin. The TPH concentration detected in these samples ranged from 0.6 mg/l in sample SW3 to 1.4 mg/l in sample SW1. PAHs, organochlorine pesticides, and PCBs were not detected in the storm water samples.

The pH of the storm water samples ranged from 7.0 in sample SW3 to 7.7 in sample SW1 and the dissolved oxygen concentration ranged from 7.2 mg/l in sample SW1 to 9.9 mg/l in sample SW2. The biological oxygen demand ranged from 4 mg/l in sample SW2 to 5 mg/l in samples SW1 and SW3. Total suspended solids concentrations ranged from 5 mg/l in sample SW1 to 13 mg/l in SW2 and SW3. Total organic carbon and dissolved organic carbon were detected at 3.6 mg/l in sample SW3 but were not detected in the storm water samples from the other locations.

2.2.4.2 Sediment Quality

Surficial Sediments. Surficial sediment samples from S1 through S7 (Figure 2-6) were analyzed for SVOCs, organochlorine pesticides, PCBs, TPH, metals, organotins, total organic carbon, and percent solids. Summary analytical results for the surficial sediment samples are summarized in Table 2-4 and analytical results for the specific metals detected are included in Table 2-5.

The sample from location S3, near outfalls G and H, contained the highest concentrations of PAHs, organochlorine pesticides, PCBs, metals, TPH, and organotins identified in the surficial sediment samples. The sample from S6, located near sewer outfalls I and J2 in the eastern portion

of the lagoon, contained the second highest concentration of PAHs. The sample from S4, located near sewer outfalls F and R, contained the second highest concentration of total PCBs. Aroclor-1254 was the PCB isomer detected in surficial sediment samples from the Seaplane Lagoon. The pesticides detected consist of alpha-chlordane; lindane; 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT. The organotins identified were dibutyltin and tributyltin.

The total organic carbon levels identified in the sediment samples ranged from 0.5 percent in S1 to 3.2 percent in S3. The percent solids identified ranged from 32.3 percent in S5 to 65.3 percent in S1.

Sediment Toxicity. Sediment toxicity was characterized for surficial sediment samples from locations S1 through S7 (Figure 2-6). Sediments from S2, S3, S5, and S7 caused significant mortality (20 percent or greater) in the amphipod *Eohaustorius estuarius*. The percent survivals in sediment samples were as follows: S1, 95 percent; S2, 56 percent; S3, 77.5 percent; S4, 92 percent; S5, 70 percent; S6, 85 percent; and S7, 75 percent. The overall survival was greatest for test organisms exposed to sediments samples from S1 and S4. The overall lowest survival was lowest for test organisms exposed to sediments from S2. All *E. estuarius* reburied in test sediments from each station.

Exposure of juvenile worms, *Naenthes arenaceodentata*, to sediments from the Seaplane Lagoon did not result in any significant reductions in survival or growth. Bioassays using the mussel *Mytilus edulis* were also conducted on sediment samples from each station. The bioassays consisted of exposing *M. edulis* larvae to elutriate prepared from the test sediment and measuring the percentage survival of the larvae and the number of larvae that develop normally without obvious malformations. Survival of larvae for each bioassay was greater than 89 percent and did not differ statistically from survival measured in the control group. The proportion of larvae that developed in a normal manner ranged from 96.7 percent to 100 percent. In a second test performed on sediment samples from S2, the larvae exposed to the sediment elutriate showed a lower rate of survival than the control group.

Bioaccumulation Studies. Based on toxicity testing performed using *E. estuarius*, surficial sediments from sampling locations S2, S3, S5, and S7 were selected for 28-day laboratory bioaccumulation studies. Tissue samples of the clam, *Mocoma nausuta*, analyzed as part of the bioaccumulation studies, were analyzed for SVOCs, organochlorine pesticides, PCBs, metals, and organotins. The summary analytical results are presented in Table 2-6. Analytical data for specific metals identified are included in Table 2-7.

Tissue samples from sampling location S3 contained the highest concentrations of total PAHs and organochlorine pesticides. The sample from S2 contained the highest concentration of total PCBs. The total concentrations of PAHs, organochlorine pesticides, and total PCBs detected were 3,767 micrograms per kilogram ($\mu\text{g/kg}$), 498 $\mu\text{g/kg}$, and 242 $\mu\text{g/kg}$, respectively. The pesticides detected consisted of alpha-chlordane; lindane; 4,4'-DDD; and 4,4'-DDE. Aroclor-1254 was the PCB mixture detected.

The concentration of total metals was similar in tissue samples from each location and ranged from 121 mg/kg to 143 mg/kg. The total concentration of organotins was also similar in tissue samples and ranged from 31 mg/kg to 97 mg/ μg . The organotins detected were tributyltin and dibutyltin.

Benthic Population Studies. Based on toxicity testing performed using *E. estuarius*, surficial sediments from locations S2, S3, S5, and S7 were also selected for benthic population studies. An average of 30 species was identified in sediments from S3; this was the highest number of species identified in sediments from the four samples. The average number of species identified in sediments from S2, S5, and S7 were 15, 15, and 17 respectively.

Seventy-six percent of the benthic biota identified at the four locations were molluscs. Molluscs also made up the majority of the biomass in samples from S3, S5, and S7. The three species responsible were the clams *Gemma gemma*, *Musculista senhousia*, and *Theora fragilis*. The majority of the biomass in the sample from S2 was composed of annelid worms even though molluscs represented 79 percent of the individuals.

Sediment Core Samples. Sediment core samples from S3, S4, and S7 (Figure 2-6) were obtained from the depths of 0 to 10 cm, 10 cm to 40 cm, 40 cm to 70 cm, and 85 cm to 95 cm. These sediment samples were analyzed for SVOCs, organochlorine pesticides, PCBs, TPH, metals, organotins, total organic carbon, percent solids, alpha radiation, and beta radiation. Summary analytical results for sediment core samples from locations S3, S4, and S7 are summarized in Tables 2-8, 2-9, and 2-10. Analytical results for the specific metals detected are included in Table 2-11.

PAHs, organochlorine pesticides, PCBs, metals, organotins, and TPH were detected in the sediment core samples. In general, the highest chemical concentrations were detected near outfalls in cores from locations S3 and S4. The concentration of the chemicals detected in cores from S3 and S4 varied with depth. Samples for the 10 to 40 cm and 85 to 95 cm depths generally exhibited the highest chemical concentrations. The sediment cores from S7 did not exhibit this same variation with depth. The pesticides detected consist of alpha-chlordane; lindane; 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT. Aroclor-1254 and Aroclor-1260 were the PCB mixtures identified in the sediment core samples. The organotins detected include dibutyltin and tributyltin.

Total organic carbon levels ranged from 1.5 percent to 10 percent. Alpha radiation levels ranged from not detected to 8 picocuries per gram (pCi/g). Beta radiation levels ranged from not detected to 11 pCi/g. The percent solids ranged from 37 percent to 45 percent.

2.3 WEST BEACH LANDFILL, SITE 2

2.3.1 Site Description and History

The West Beach Landfill (Site 2) occupies approximately 110 acres in the southwestern corner of NAS Alameda (Figure 2-1). It is bounded on the west and south by San Francisco Bay; to the north and east the site is fenced from Perimeter Road and the Runway Area. The southwest portion of the site is located in San Francisco County and the remainder of the site is located within Alameda County. The landfill is surrounded by an earthen berm that is approximately 55 feet wide and stands about 7 feet above the landfill surface. The refuse area is moderately to well vegetated.

A portion of this site was designated a wetland in 1985 (Figure 2-7). This portion of the site has been created almost entirely of dredged material. Based on a full wetland delineation conducted in 1993, the jurisdictional wetlands encompass 16.9 acres with approximately 5.4 acres of open water noted in the spring of 1992 (PRC, 1994b). The amount of open water varies with season and rainfall. Generally, the wetland area increases and the open water area decreases during the dry season; the water likely originates from seasonal ponding of precipitation, tidal bay water entering the area via a 36-inch culvert, and groundwater. The water is brackish. Much of the wetland habitat followed the five-foot contour interval.

2.3.1.1 Fill History

Construction of the seawall along the southern and western sides of Site 2 began in 1956 along with the placement of hydraulic sand fill material. The average thickness, determined through drilling, is 27 feet on the eastern side and 46 feet on the western side. Generally, the northern half of the site and the northeastern portion of southern half have been used for disposal purposes since that time; the remainder of the southern portion has been used for disposal of dredge spoils. In

June 1985, the Navy notified the Regional Water Quality Control Board (RWQCB) that a slurry wall had been installed along a portion of the western perimeter of the landfill to prevent seepage of leachate into the bay. In 1986, an earthen berm approximately 15 feet wide and 5 feet high was constructed around Site 2. (PRC, 1994b).

To comply with the requirements of Order No 83-85 from the RWQCB for the closure of the landfill, the Navy constructed a cover for the landfill. Borrow material for the cover was initially dredged from the southwestern portion of the site. However, in 1985 the Navy informed the RWQCB that the southwestern portion of the landfill had been declared a wetland and use of this area for borrow material was discontinued. In 1986, 20,000 cubic yards of imported material were placed on the landfill. In December 1986, the Navy graded the cover to prevent ponding of water.

2.3.1.2 Disposal History

The West Beach Landfill received almost all of the waste generated by the base from 1952 through March 1978 as well as minor amounts of wastes from other naval facilities in the San Francisco Bay area, including the Oak Knoll Naval Hospital (now the Oakland Naval Hospital). Approximately 1.6 million tons of waste were disposed of at the landfill and approximately 30,000 to 500,000 tons of this waste was considered hazardous. The waste disposal method consisted of excavating a trench to approximately 20 feet bgs in the hydraulic fill and placing the waste material in the trench. The wastes were spread and compacted by a bulldozer and were intermittently covered with excavated soil. During the late 1970s, the primary disposal method changed to excavating to the water table and then filling with waste.

Known materials that were disposed include waste chemical drums; municipal garbage; solvents; oily waste and sludges; paint waste, strippers, thinners, and sludges; plating wastes; industrial strippers and cleaners; acids; mercury; PCB-contaminated fluids and rags; batteries; low-level radiological wastes; scrap metal; inert ordnance; creosote; dredge spoils; waste medicines and reagents; spoiled food; asbestos; pesticides (solid and liquid); tear gas agent ortho-chlorobenzylidene malononitrile; and infectious waste. The estimated quantities of particular materials that were disposed of in the landfill were presented in the E&E Initial Assessment Study. Disposal of hazardous materials was discontinued by the early 1970s (HLA, 1978).

Disposal of all wastes ceased in March 1978 and the Navy proceeded with plans to close the landfill as a class II disposal facility in accordance with applicable local and state regulations. As part of these plans, several investigations (discussed in section 2.3.2) were conducted to evaluate soil and groundwater quality. The disposal area is currently moderately to well vegetated with grasses and supports a variety of wildlife (PRC, 1994a).

2.3.3 Previous Investigations

Investigations were conducted at Site 2 to evaluate soil and groundwater quality in support of closure of the landfill as a Class II disposal facility. These investigations are described as follows:

- In 1977, Harding Lawson Associates (HLA) performed an investigation to evaluate whether the landfill at Site 2 was in compliance with existing regulations and to make recommendations to correct any deficiencies (HLA, 1978). The investigation included the installation of 20 borings (1 through 20) using a drilling rig or a hand auger. These borings were installed in and around the landfill as shown on Figure 2-8. Borings 1 through 13 and 17 through 20 were converted to monitoring wells. Two samples of bay water were also analyzed. The groundwater and bay water samples were analyzed for oil and grease, selected metals, and water quality parameters; the report of this investigation also included analytical results for samples collected in 1976. Combustible gas measurements were obtained from monitoring wells 1 through 12 and 17 through 19 and samples from selected wells were analyzed using gas chromatography for oxygen, nitrogen, carbon dioxide, and five hydrocarbons including

methane. Gas samples from other selected wells were also analyzed by gas chromatography for oxygen, nitrogen, carbon dioxide, and methane. HLA also estimated seepage rates to the Bay as part of this investigation. The results of this investigation are not discussed further in this Work Plan.

- In July 1983, Ecology and Environment installed monitoring wells 20 through 25 within the limits of the landfill in the locations shown on Figure 2-8. As part of this investigation, groundwater samples from the newly installed monitoring wells and existing monitoring wells 3, 8, 9, and 19 were collected and analyzed. These were the only previously installed wells that could be located. The groundwater samples were analyzed for VOC, SVOCs, pesticides, and metals. A magnetometer survey was also conducted as part of this investigation to investigate the potential presence of buried drums. The results of this investigation are not discussed further in this Work Plan.
- The initial Solid Waste Assessment Test (SWAT) investigation conducted at Site 2 by Canonie, in 1990, included the installation of four borings (WB-1 to WB-4) into the late Pleistocene estuarine deposits (Canonie, 1990). These borings were drilled at the northwestern, northeastern, and southwestern corners of the landfill in the locations shown on Figure 2-8. Soil samples from these borings were selectively analyzed for asbestos, SVOCs, VOCs, metals, mercury, organochlorine pesticides, PCBs, pH, radiation, and total organic carbon. The results of this investigation are not discussed further in this Work Plan.
- During a subsequent SWAT investigation in 1991, the PRC team collected 151 surface soil samples (Figure 2-9); 12 wetland sediment samples (Samples 301SD through 312SD, Figure 2-7); 23 wetland surface water samples (Samples 301SW through 323SW, Figure 2-7); and subsurface soil samples from Site 2 for chemical analysis. Surface soil samples were analyzed for SVOCs, organochlorine pesticides, PCBs, total recoverable petroleum hydrocarbons (TRPH), metals, and radionuclides. Wetland sediment samples were analyzed for each of these constituents except radionuclides. Subsurface soil from the soil borings was also analyzed. Samples from the fill material were analyzed for VOCs, SVOCs, organochlorine pesticides, PCBs, TRPH, oil and grease, metals, asbestos, and radionuclides. Subsurface soil samples collected from the late Pleistocene/Holocene alluvial/eolian deposits and Holocene estuarine deposits (second water-bearing zone) were analyzed for VOCs, SVOCs, organochlorine pesticides, PCBs, TRPH, oil and grease, metals, asbestos, and radionuclides. The results of surface soil, sediment, and water sampling are discussed further in Section 2.3.6. The results of subsurface sampling are not discussed further in this work plan.
- In 1993, PRC obtained surficial sediment samples of the top 10 cm of sediments from seven locations (W1 through W7) and water samples from three locations (W2, W3, and W6); sample locations are shown on Figure 2-7 (PRC, 1994). Bioassays were conducted on these samples. Bioaccumulation studies and analyses of benthic populations for species diversity were performed for those sediment samples (W4, W5, W6, and W7) that exhibited significant effects in the bioassay.

2.3.4 Site/Geology and Hydrogeology

2.3.4.1 Geology

The primary geologic units encountered at Site 2 consist of artificial fill, Holocene Bay Mud, and the late Pleistocene/Holocene deposits. The lateral and vertical relationships of these units at Site 2 are illustrated on the cross sections constructed in the locations shown on Figure 2-10 and provided on Figures 2-11 and 2-12.

Site 2 is underlain by approximately 15 to 40 feet of fill material consisting primarily of poorly graded sand, silty sands, and clays. The fill is thickest along the western boundary of Site 2. This

unit is underlain by Holocene Bay Mud consisting mostly of silt and clay with sand lenses. In the southwest corner of Site 2, the Holocene Bay Mud unit is silty sand with little or no clay. The thickness of the Holocene Bay Mud varies from 5 to 40 feet (PRC and MW, 1995). The Holocene Bay Mud is underlain by the late Pleistocene/Holocene deposits. These deposits consist of 25 to 60 feet of clayey sand to silty sand interbedded with clays and silts.

2.3.4.2 Hydrogeology

The first water bearing zone at Site 2 is unconfined and occurs within the fill materials overlying the Holocene Bay Mud unit which acts as a confining layer between the first and second water bearing zones. The second water-bearing zone occurs under confined conditions within the late Pleistocene estuarine deposits beneath the Holocene Bay Mud. The clayey portion of the Holocene Bay Mud is not present along the western corner of the site in the vicinity of monitoring well cluster M-019; the hydraulic separation between the two water-bearing zones is possibly leaky in this area.

The reported results of in situ slug tests performed in groundwater monitoring wells at Site 2 indicate that the hydraulic conductivity of the first water-bearing zone ranges from $5.2\text{E-}05$ centimeter per second (cm/s) to $5.5\text{E-}02$ cm/s and that the transmissivity of the second water-bearing zone ranges from $3.8\text{E-}02$ cm²/s to 3.04 cm²/s. Laboratory measurements of hydraulic conductivities indicate lower hydraulic conductivities than measured with the slug tests. Laboratory results for the first water bearing zone ranged from $3.1\text{ E-}08$ cm/s to $1.5\text{ E-}05$ cm/s and for the second water-bearing zone ranged from $4.9\text{ E-}09$ cm/s to $3.1\text{ E-}08$ cm/s (PRC and MW, 1995). Laboratory soil classifications and measured values of the moisture content, dry density, specific gravity, cation exchange capacity, and effective stresses of selected subsurface soil samples from Site 2 were also determined.

Potentiometric surface, or water level, contour maps constructed for Site 2 using data from the 1992 tidal influence study are presented as Figures 2-13 and 2-14 for the first and second water-bearing zones, respectively. Elevation datum on these figures is mean lower low water (MLLW). These contours indicate that groundwater flow directions in both the first and second water-bearing zones are generally westernly, toward the Bay.

Tidal influence studies have been conducted to assess the magnitude and extent of tidal influences on groundwater levels in the first water-bearing zone (fill material), and the second water-bearing zone at Site 2. These studies were conducted during the monthly high and low tides (PRC and MW, 1995).

The study completed at Site 2 included monitoring the water levels in six well clusters and an additional nine shallow wells. The monitoring well clusters consist of well pairs M-010A/M-010B; M-012A/M-012B; M-014A/M-014B; M-016A/M-016B; M-020A/M-020B; and M-023A/M-023B. The additional nine shallow wells monitored include M-011A, M-013A, M-015A, M-017A, M-018A, M-019A, M-021A, M-022A, and M-024A. The shallow monitoring wells are designated with an A and are completed in the artificial fill which comprises the first water-bearing zone. The deep monitoring wells are designated with a B or C and are completed in the late Pleistocene/Holocene deposits of the second waterbearing zone.

Figures 2-13 and 2-14 include bar graphs to illustrate the amount of tidal fluctuation measured at each well. For graphical clarity, no bar graphs were presented for wells that had water level fluctuations of less than 0.1 feet. Water levels in both water-bearing zones at Site 2 were tidally influenced. In general, water levels in the second water-bearing zone wells responded more quickly, but with less amplitude, to tidal influences than did the water levels in the first water-bearing zone wells. The rapid response of the second water-bearing zone to tidal fluctuations is primarily due to the confined nature of the zone.

During the tidal influence study, a downward gradient between the first and second water-bearing zones was observed at all cluster wells along the east margin of Site 2, with the exception of well cluster M-O10. At well cluster M-O10, a potential upward vertical head of 0.35 feet was indicated. The hydraulic head differences measured in well clusters M-020 and M023 reversed cyclically during recorded tidal cycles. The reversal occurred when the water level in the first water-bearing zone wells fluctuated with greater magnitude than did the water levels in the second water bearing zone wells (PRC and MW, 1995).

The water levels in the bay, measured at Pier 4, fluctuated approximately 9 feet, from 7.69 feet above MLLW at high tide, to 1.86 feet below MLLW at low tide during the duration of the tidal influence study.

Vertical gradients between the first and second water-bearing zones were evaluated for well clusters at Site 2 using water levels measured during three quarters of 1995 (January, April, and July). In the eastern portion of Site 2 at well clusters M-010, M-012, and M-014, a downward vertical gradient between the first and second water-bearing zones was observed at all well clusters, except at well cluster M-010 where the vertical gradient was upward in April and July, 1995. It is assumed that tidal influence is the cause for the reversal of vertical gradient at well cluster M-010.

Along the San Francisco Bay shore at Site 2 at well clusters M-020 and M-023, the vertical gradient between the first and second water-bearing zones was downward most of the time, except for well cluster M-020 in July and for well cluster M-023 in April. The hydraulic heads were equal in monitoring wells M-020A and M-020B in January.

2.3.5 Summary of Analytical Data

The results of the ecological assessment conducted in 1993 (PRC, 1994a) and SWAT investigation conducted in 1991 (PRC, 1994b) were reviewed to assess the water and sediment quality within the West Beach Landfill Wetlands and identify the distribution of chemicals. The review included assessment of the data presented in the reports; an independent assessment of the raw data was not conducted. The results of this review have been used in later sections to select appropriate sampling locations for this treatability study.

To simplify the discussion of the data and identify the general distribution of chemicals in the water and sediment, data summary tables (Tables 2-12 through 2-16) provided in this section include the total concentrations of PAHs, PCBs, organochlorine pesticides, and organotins detected in each sample based on the analytical results presented in the report prepared for the ecological assessment (PRC, 1994). Specific metals are identified where appropriate. Although samples were generally analyzed for SVOCs, the primary SVOCs of concern are PAHs and the discussion below is limited to the total PAH concentrations identified.

2.3.5.1 Surface Water Quality

During the SWAT investigation, 23 wetland surface water samples (Samples 301SW through 323SW, Figure 2-7) were analyzed for VOCs; SVOCs; organochlorine pesticides; PCBs; TPH; metals; total organic carbon; the anions chloride, fluoride, and sulfate; and the physical parameters acidity, alkalinity, hardness, total dissolved solids, specific conductivity, and temperature. With the exception of acetone, chloromethane, and methylene chloride which are common laboratory contaminants, VOCs were not detected in the samples. No PAHs, organochlorine pesticides, or PCBs were detected and TPH was only detected in one water sample (323SW) at 0.3 mg/l. No anomalous metals concentrations were noted. Specific analytical results for metals, total organic carbon, anions, and physical parameters are presented in the SWAT report (PRC, 1994b).

During the ecological assessment, water samples from three locations (W2, W3, and W6 shown on Figure 2-7) were analyzed for SVOCs, organochlorine pesticides, PCBs, TPH, total and dissolved metals, organotins, chemical oxygen demand, biological oxygen demand, total suspended solids, dissolved organic carbon, and total organic carbon. The summary analytical results are presented in Table 2-12.

PAHs, organotins, organochlorine pesticides, PCBs, and dissolved metals were not detected in the surface water samples collected during the ecological assessment. Total metals were only detected in the surface water sample from location W3; beryllium was the only metal detected and the concentration was 3 µg/l. The chemical oxygen demand ranged from 680 mg/l in the sample from location W4 to 847 mg/l in the sample from W3; the biological oxygen demand ranged from 3 mg/l in the sample from W3 to 11 mg/l in the sample from W4; total suspended solids ranged from 8 mg/l in the sample from W2 to 12 mg/l in the sample from W4; total organic carbon ranged from 13 mg/l in the samples from W3 and W4 to 27 mg/l in the sample from W2; and dissolved organic carbon ranged from 12 mg/l in samples from W3 and W4 to 25 mg/l in the sample from W2.

2.3.5.2 Surface Soil and Sediment Quality

Surface soil samples collected from 150 locations within the West Beach Landfill (samples A-201 through N-210) were analyzed for SVOCs, organochlorine pesticides, PCBs, TRPH, metals, and radionuclides. The distribution of total PAHs, total PCBs, and total organochlorine pesticides are shown on Figures 2-15, 2-16, and 2-17, respectively. These figures show no discernable pattern of a source to the wetlands, and is consistent with chemical transport by overland erosion or by the chemicals being present on fill soils. The data are summarized as follows:

- The concentrations of total PAHs (Figure 2- 15) ranged from not detected to 17,380 µg/kg in the soil sample from location F-200; the distribution of total PAHs in these soil samples was irregular. In general, most concentrations were below 1,000 µg/kg; only 12 samples contained total PAH concentrations greater than 1,000 µg/kg.
- The concentrations of total PCBs (Figure 2-16) ranged from not detected to 4,000 µg/kg in the soil sample from location C-206. The distribution of total PCBs in the surface soil samples was irregular. In general, most concentrations were below 400 µg/kg; only three soil samples contained total PCBs at concentrations greater than 1,000 µg/kg. The PCB mixtures detected were Aroclor- 1248 and Aroclor- 1260.
- The concentrations of total organochlorine pesticides (Figure 2- 1 7) ranged from not detected to 675 µg/kg in the soil sample from location D-205. The distribution of total organochlorine pesticides in the surface soil samples was irregular. The pesticides detected include 4,4'-DDD; 4,4'-DDE; 4,4'-DDT; dieldrin; endrin; endrin ketone; heptachlor; heptachlor epoxide; alpha-chlordane; and lindane.
- TRPH was identified in the majority of the surface soil samples; only eight soil samples contained TRPH at concentrations greater than 1,000 mg/kg. Of the metals analyzed, only arsenic, cadmium, copper, and mercury exceeded the typical range for metals in soil; the concentrations were within the limits for the extreme range. Gross alpha radiation levels ranged from not detected to 14.1 pCi/g; gross beta radiation levels ranged from not detected to 12.5 pCi/g; radium-226 levels ranged from 0.6 pCi/g to 13.0 pCi/g; and radium 228 levels ranged from not detected to 1.0 pCi/g.

Wetland sediment samples collected from locations 301SD through 312SD within the West Beach Landfill Wetland (Figure 2-7) were analyzed for VOCs, SVOCs, organochlorine pesticides, PCBs, TRPH, and metals. With the exception of acetone, a common laboratory contaminant, no VOCs were identified in the sediment samples. Fluoranthene and pyrene were the only PAHs identified in

the sediment samples. The total concentrations ranged from not detected to 480 µg/kg in sample 304SD. The only pesticides identified were 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT; the total concentration ranged from not detected to 898 µg/kg in sample 304SD. Aroclor-1260 was the only PCB isomer identified, the maximum concentration was 260 µg/kg in the duplicate sample from location 310SD. TRPH concentrations ranged from not detected to 85.8 mg/kg in sample 309SD. Of the metals analyzed, only arsenic and mercury exceeded the typical range for background concentrations of metals, although these concentrations were within the limits for the extreme range.

During the ecological assessment, surficial wetland sediment samples from seven locations (W1 through W7 shown on Figure 2-7) were analyzed for SVOCs, organochlorine pesticides, PCBs, TPH, metals, organotins, total organic carbon, and percent solids. The summary analytical results are presented in Table 2-13, analytical results for specific metals identified in the samples are included in Table 2-14. The following is a summary of the analytical results:

- Total PAH concentrations in these wetland sediment samples ranged from not detected in the sample from W2 to 2,600 µg/kg in the sample from W6.
- The total concentration of PCBs ranged from not detected to samples from W1 and W2 to 435 µg/kg in sample from W5; the PCB mixtures detected include Aroclor- 1254 and Aroclor-1260.
- The total concentration of pesticides detected ranged from not detected in samples from W1 and W2 to 16 µg/kg in the sample from W5. The pesticides detected in the samples include 4,4'-DDE and alpha chlordane.
- The TPH concentrations ranged from not detected in samples from W1, W2, and W3 to 543 mg/kg in the sample from W6.
- The total metals concentrations detected in wetland sediment samples ranged from 112 mg/kg to 572 mg/kg.
- The total organic carbon levels ranged from 0.3 percent in the sample from W 1 to 1.1 percent in the sample from W4.
- The percent solids values ranged from 46.3 percent in the sample from W6 to 81.3 in the sample from W 1.
- Organotin data were not included in the information supplied to UCB.

Sediment Toxicity. Sediment toxicity was characterized for sediment samples from locations W1 through W7 (Figure 2-7). Sediments from W4, W5, W6, and W7 caused significant mortality (20 percent or greater) in the amphipod *Eohaustorius estuarius*; the lowest rate of survival was for organisms exposed to sediments from W4. The percent survivals were as follows: W1, 96.7 percent; W2, 97 percent; W3, 98.3 percent; W4, 34 percent; W5, 49.2 percent; W6, 51 percent; and W7, 78 percent. Reburial of *E. estuarius* exposed to sediments from each location ranged from 96 percent to 100 percent. Exposure of juvenile worms, *Naenthes arenaceodentata*, to sediments from the West Beach Landfill Wetland did not result in any significant reductions in survival or growth.

Bioaccumulation Studies. Based on toxicity testing performed using *E. estuarius* and the results of chemical analyses, locations W4, W5, W6, and W7 were selected for bioaccumulation studies. Tissue samples of the clam, *Macoma nausuta*, analyzed as part of the bioaccumulation studies were analyzed for SVOCs, organochlorine pesticides, PCBs, metals, and organotins. The summary

analytical results are presented in Table 2-15 and analytical data for specific metals identified are summarized in Table 2-16.

Tissue samples from location W5 contained the highest concentrations of organochlorine pesticides, PCBs, and metals: concentrations detected were 83 µg/kg, 426 µg/kg, and 140 mg/kg, respectively. The pesticides detected consisted mixtures of lindane; 4,4'-DDD; and 4,4'-DDE. Aroclor-1254 and Aroclor-1260 were the PCBs detected. PAHs were not detected in any of the tissue samples. Organotins were identified in tissue samples from W4 and W7. Dibutyltin was the only organotin identified.

Benthic Population Studies. Based on toxicity testing performed using *E. estuarius* and the results of chemical analyses, locations W4, W5, W6, and W7 were selected for benthic population studies. An average of two species were identified in sediments from each West Beach Landfill Wetland sediment sample. The greatest number of species identified was in sediments from location W4 (eight species) and the smallest number of species identified was in sediments from location W5 (two species). The most common species identified were unidentified oligochaete worms and the polychaete worms *Polydora cornuta* and *Capitella capitata*. The biomass of the benthic organisms within these sediments was dominated primarily by three common oligochaete and polychaete worms. Mean abundance estimates averaged about 14 organism per station and the overall diversity was low.

2.4 REFERENCES FOR HISTORY OF OPERATION

Canonie, 1990. Feasibility Study Plan RI/FS

Harding Lawson Associates, 1978. Sanitary Landfill Site Study

PRC. 1994a Ecological Assessment Draft Report, dated 17 February 1994; Ecological Assessment. Draft Report Amendment, dated 1 July, 1994

PRC. 1994b Solid Waste Water Quality Assessment Test (SWAT) Report. RI/FS Phase 5 and 6. Final 1994

PRC. 1991 CLEAN (West Beach Landfill and Runway Areas.)

PRC and MW. 1995 RI/FS Aquifer Testing Work Plan. Final

**TABLES
&
FIGURES**

Table 2.1 Summary of Sources of Hazardous Materials near Seaplane Lagoon.

Source: PRC 2/94

IRP Site	Building	Building Description	Documented Chemicals Used	Discharge to	Outfall to	Comments
6	41	Hangar Aircraft Maintenance	PD680 (petroleum hydrocarbon solvent) Trichlorofluoroethane Hydraulic Oil Trichloroethane Paint wastes Used Hydraulic Oils Dry Cleaner	Storm Drain	Seaplane Lagoon	no documented spills or signs of contamination no discharge to combined system but adjacent storm drain collects runoff from site possible discharge of rinse waters into existing EBMUD wastewater system
8	114	Maintenance Shop Paint Shop Steam Cleaning Shop Storage Facility for Pesticides and Herbicides	chlordan lindane DDT malathion diazinon telvar chlorvar 2,4-D Roundup Princep Krovar I	Storm Drain	Seaplane Lagoon	1,000 liters per day of wastewater from steam cleaning, paint stripping and painting were discharged directly to storm drains contents of malfunctioning separator pits were routinely dumped at the West Beach Landfill (Site 2)
10	400	Paint Shop Cleaning Shop Previous Missile Rework Facility	sludge metal shavings paint strippers cleaning solvents oils and grease heavy metals phenols	Industrial wastewater collection system		Untreated wastewater was discharged to industrial wastewater collection system Wastes were deposited at West Beach Landfill (Site 2)
11	14	Engine test cell	mercury			Laboratories have had mercury spills in the past. Waste generated from cleanup was disposed of at West Beach Landfill (Site 2) old underground fuel storage tanks are present at site
18	-	Storm sewer system	plating bath dumps paints paint strippers pesticides/herbicides oils and grease cleaning solvents PCB contaminated oils		Seaplane Lagoon	The storm sewer system is reported to be in poor condition and may leak. Untreated wastes were discharged to system prior to 1975, since that time these wastewaters have been discharged to the separated sanitary sewer system

TABLE 2-2
SUMMARY OF PREVIOUS ANALYTICAL RESULTS
WATER SAMPLES
SITE 17, SEAPLANE LAGOON

	LAGOON WATER SAMPLES			STORM WATER SAMPLES		
	Sampling Station			Sampling Station		
	S3	S4	S7	SW1	SW2	SW3
TOTAL PAHS ($\mu\text{g/l}$)	ND	ND	ND	ND	ND	ND
TOTAL METALS ($\mu\text{g/l}$)	97	100	134	191	90	143
TOTAL DISSOLVED METALS ($\mu\text{g/l}$)	ND	ND	ND	136	62	71
TOTAL ORGANOTINS ($\mu\text{g/l}$)	ND	ND	ND	ND	103	0.02
TPH (mg/l)	1.6	1.7	1.8	1.4	0.7	0.6
ORGANOCHLORINE PESTICIDES AND PCBS ($\mu\text{g/l}$)	ND	ND	ND	ND	ND	ND
MISCELLANEOUS MEASUREMENTS						
Biological Oxygen Demand (mg/l)	2	2	1.7	5	4	5
Total Suspended Solids (mg/l)	4	4	4	5	13	13
TOTAL ORGANIC CARBON						
Dissolved Organic Carbon (mg/l)	ND	ND	ND	ND	ND	3.6
Total Organic Carbon (mg/l)	ND	ND	ND	ND	ND	3.6
CHARACTERISTIC MEASUREMENTS						
Salinity (ppt)	26.3	26.3	26.3	NA	NA	NA
Dissolved Oxygen (mg/l)	8.7	9.8	7.6	7.2	9.9	8.4
pH (-)	NA	NA	NA	7.7	7.6	7.0

Notes:

ND: Not Detected

NA: Not Analyzed

Source:

PRC, 1994a

Ecological Assessment

TABLE 2-3

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
WATER SAMPLES
SITE 17, SEAPLANE LAGOON**

METALS DATA

	LAGOON WATER SAMPLES			STORM WATER SAMPLES		
	Sampling Station			Sampling Station		
	S3	S4	S7	SW1	SW2	SW3
TOTAL METALS						
Cadmium (µg/l)	ND	ND	ND	8	ND	ND
Chromium (µg/l)	ND	50	8	ND	ND	ND
Copper (µg/l)	ND	ND	ND	19	ND	8
Lead (µg/l)	3	2	3	12	13	15
Zinc (µg/l)	94	48	123	160	77	120
TOTAL	97	100	134	199	90	143
TOTAL DISSOLVED METALS						
Cadmium (µg/l)	ND	ND	ND	5	ND	ND
Lead (µg/l)	ND	ND	ND	3	ND	ND
Zinc (µg/l)	ND	ND	ND	128	62	71
TOTAL	ND	ND	ND	136	62	71

Notes:

ND: Not Detected

Source:

PRC, 1994a

TABLE 2-4
SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SURFICIAL SEDIMENT SAMPLES
SITE 17, SEAPLANE LAGOON

	Sampling Station						
	S1	S2	S3	S4	S5	S6	S7
TOTAL PAHS (µg/kg)	473	1,528	43,147	1,701	1,345	11,943	1,394
TOTAL METALS (mg/kg)	358	419	1,383	514	602	545	509
TOTAL ORGANOTINS (µg/kg)	7	8	330	23	7	22	0
TPH (mg/kg)	225	160	3,373	697	203	3,747	139
TOTAL ORGANOCHLORINE PESTICIDES (µg/kg)	13	5	238	17	4	47	2
TOTAL PCBS (µg/kg)	212	84	798	385	119	182	119
PERCENTAGE SOLIDS (%)	65	55	39	62	32	51	39
TOTAL ORGANIC CARBON (%)	1	1	3	1	2	1	1

Source:
PRC, 1994a

TABLE 2-5

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SURFICIAL SEDIMENT SAMPLES
SITE 17, SEAPLANE LAGOON**

METALS DATA

	Sampling Station						
	S1	S2	S3	S4	S5	S6	S7
TOTAL METALS							
Antimony (mg/kg)	13.8	0.7	39.8	17.1	33.1	19.8	30.3
Arsenic (mg/kg)	4.1	6.0	10.9	4.1	12.6	7.3	11.2
Beryllium (mg/kg)	ND	0.3	0.3	0.2	0.4	0.2	0.4
Cadmium (mg/kg)	3.5	0.5	28.2	2.2	2.8	4.0	0.5
Chromium (mg/kg)	130.0	113.3	400.0	223.3	182.5	166.7	165.0
Copper (mg/kg)	29.8	41.3	132.5	36.6	66.6	54.0	56.5
Lead (mg/kg)	37.1	33	342.5	73.7	40.9	69.6	32.6
Mercury (mg/kg)	0.26	0.39	0.81	0.27	0.55	0.36	0.46
Nickel (mg/kg)	36.8	63.3	81.8	41.9	82.3	62.3	73.8
Selenium (mg/kg)	ND	0.2	0.4	ND	0.2	ND	ND
Silver (mg/kg)	0.7	0.5	6.1	3.9	0.4	0.8	0.4
Thallium (mg/kg)	ND	ND	ND	ND	ND	ND	ND
Zinc (mg/kg)	101.5	160	340	111.1	180	160	137.4
TOTAL	358	419	1,383	514	602	545	509

Notes:

ND: Not Detected

Source:

PRC, 1994a

TABLE 2-6
SUMMARY OF PREVIOUS ANALYTICAL RESULTS
TISSUE SAMPLES FROM LABORATORY BIOACCUMULATION STUDIES
SITE 17, SEAPLANE LAGOON

	Sampling Station			
	S2	S3	S5	S7
TOTAL PAHS ($\mu\text{g/kg}$)	ND	3,767	ND	ND
TOTAL METALS (mg/kg)	143	128	126	121
TOTAL ORGANOTINS ($\mu\text{g/kg}$)	82	71	97	31
TOTAL ORGANOCHLORINE PESTICIDES ($\mu\text{g/kg}$)	18	498	ND	ND
TOTAL PCBS ($\mu\text{g/kg}$)	278	242	ND	ND

Notes:

ND: Not Detected

Source:

PRC, 1994a

TABLE 2-7
SUMMARY OF PREVIOUS ANALYTICAL RESULTS
TISSUE SAMPLES FROM LABORATORY BIOACCUMULATION STUDIES
SITE 17, SEAPLANE LAGOON

METALS DATA

	Sampling Station			
	S2	S3	S5	S7
TOTAL METALS				
Arsenic (mg/kg)	21.2	21.6	22.3	22.8
Chromium (mg/kg)	3.2	ND	ND	ND
Copper (mg/kg)	11.9	11.1	10.1	10.8
Lead (mg/kg)	2.9	5.3	1.6	1.2
Mercury (mg/kg)	0.2	0.1	0.1	0.1
Nickel (mg/kg)	3.8	6.7	3.5	4.2
Zinc (mg/kg)	99.9	83.6	88.7	82.3
TOTAL	143	128	126	121

Notes:

ND: Not Detected

Source:

PRC, 1994a

TABLE 2-8

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SEDIMENT CORE SAMPLES, SAMPLING STATION S3
SITE 17, SEAPLANE LAGOON**

	Sampling Depth (cm)			
	0-10	10-40	40-70	85-95
TOTAL PAHS ($\mu\text{g/kg}$)	NDA	23,840	92,930	54,470
TOTAL METALS (mg/kg)	1,561	5,366	2,974	10,607
TOTAL ORGANOTINS ($\mu\text{g/kg}$)	320	480	97	310
TPH (mg/kg)	4,200	90,000	26,000	180,000
TOTAL ORGANOCHLORINE PESTICIDES ($\mu\text{g/kg}$)	321	5,480	678	2,873
TOTAL PCBS ($\mu\text{g/kg}$)	1,231	12,051	3,867	8,108
PERCENTAGE SOLIDS (%)	39	39	45	37
TOTAL ORGANIC CARBON (%)	3.7	10.0	4.5	6.2
ALPHA RADIATION (pCi/gm)	ND	1	ND	ND
BETA RADIATION (pCi/gm)	1	5	ND	3

Notes:

NDA: No Data in Amendment

ND: Not Detected

Source:

PRC, 1994a

TABLE 2-9

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SEDIMENT CORE SAMPLES, SAMPLING STATION S4
SITE 17, SEAPLANE LAGOON**

	0-10	Sampling Depth (cm)		
		10-40	40-70	85-95
TOTAL PAHS ($\mu\text{g/kg}$)	NDA	5,480	3,540	8,990
TOTAL METALS (mg/kg)	1,597	5,024	3,531	4,983
TOTAL ORGANOTINS ($\mu\text{g/kg}$)	196	204	62	72
TPH (mg/kg)	1,800	61,000	10,000	89,000
TOTAL ORGANOCHLORINE PESTICIDES ($\mu\text{g/kg}$)	103	482	432	521
TOTAL PCBS ($\mu\text{g/kg}$)	2,211	6,000	5,000	6,564
PERCENTAGE SOLIDS (%)	38	45	34	39
TOTAL ORGANIC CARBON (%)	2.5	5.1	5.5	5.5
ALPHA RADIATION (pCi/gm)	1	8	1	8
BETA RADIATION (pCi/gm)	5	11	4	20

Notes:

NDA: No Data in Amendment

Source:

PRC, 1994a

TABLE 2-10

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SEDIMENT CORE SAMPLES, SAMPLING STATION S7
SITE 17, SEAPLANE LAGOON**

	Sampling Depth (cm)			
	0-10	10-40	40-70	85-95
TOTAL PAHS ($\mu\text{g/kg}$)	NDA	430	2,450	1,270
TOTAL METALS (mg/kg)	NDA	NDA	NDA	NDA
TOTAL ORGANOTINS ($\mu\text{g/kg}$)	0	47	150	41
TPH (mg/kg)	99	85	190	840
TOTAL ORGANOCHLORINE PESTICIDES ($\mu\text{g/kg}$)	ND	ND	7	18
TOTAL PCBS ($\mu\text{g/kg}$)	97	228	457	682
PERCENTAGE SOLIDS (%)	38	43	44	44
TOTAL ORGANIC CARBON (%)	1.5	1.6	1.8	2.1
ALPHA RADIATION (pCi/gm)	ND	2	ND	1
BETA RADIATION (pCi/gm)	3	7	2	7

Notes:

NDA: No Data in Amendment

ND: Not Detected

Source:

PRC, 1994a

TABLE 2-11

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SEDIMENT CORE SAMPLES
SITE 17, SEAPLANE LAGOON**

METALS DATA

	Sampling Station S3				Sampling Station S4			
	Sampling Depth (cm)				Sampling Depth (cm)			
	0-10	10-40	40-70	85-95	0-10	10-40	40-70	85-95
TOTAL METALS								
Antimony (mg/kg)	36.0	31.6	41.3	37.4	34.1	41.6	52.8	49.1
Arsenic (mg/kg)	14.3	11.1	17.8	7.4	10.5	9.6	9.1	8.8
Beryllium (mg/kg)	ND	ND	ND	ND	ND	0.25	ND	ND
Cadmium (mg/kg)	29	230	110	1,400	96.22	440	260	330
Chromium (mg/kg)	320	880	650	2,900	600	2100	1500	1900
Copper (mg/kg)	150	350	210	620	94.45	170	150	140
Lead (mg/kg)	440	2,800	1,100	4,000	300	900	569.82	1000
Mercury (mg/kg)	0.7	1.8	1.6	2.6	0.3	1.4	1.4	0.9
Nickel (mg/kg)	120	170	130	110	89	130	130	130
Selenium (mg/kg)	0.32	0.30	0.30	ND	0.32	0.76	0.99	0.39
Silver (mg/kg)	0.65	21.44	12.58	130.00	12.12	30.86	27.61	23.58
Thallium (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (mg/kg)	450	870	700	1,400	360	1,200	830	1,400
TOTAL	1,561	5,366	2,974	10,607	1,597	5,024	3,531	4,983

Notes:

ND: Not Detected

Source:

PRC, 1994a

TABLE 2-12

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SURFACE WATER SAMPLES
SITE 2, WEST BEACH LANDFILL**

	Sampling Station		
	W2	W3	W4
TOTAL PAHS ($\mu\text{g/l}$)	ND	ND	ND
TOTAL METALS ($\mu\text{g/l}$)	ND	3	ND
TOTAL ORGANOTINS ($\mu\text{g/l}$)	ND	ND	ND
TPH (mg/l)	ND	ND	ND
ORGANOCHLORINE PESTICIDES AND PCBS ($\mu\text{g/l}$)	ND	ND	ND
MISCELLANEOUS MEASUREMENTS			
Biological Oxygen Demand (mg/l)	4	3	11
Total Suspended Solids (mg/l)	8	12	10
TOTAL ORGANIC CARBON			
Dissolved Organic Carbon (mg/l)	25	12	12
Total Organic Carbon (mg/l)	27	13	13

Notes:

ND: Not Detected

Source:

PRC, 1994b

TABLE 2-13

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SURFICIAL SEDIMENT SAMPLES
SITE 2, WEST BEACH LANDFILL**

	Sampling Station						
	W1	W2	W3	W4	W5	W6	W7
TOTAL PAHS ($\mu\text{g/kg}$)	1,893	0	1,268	1,477	1,972	2,565	1,291
TOTAL METALS (mg/kg)	112	131	156	572	516	308	327
TOTAL ORGANOCHLORINE PESTICIDES ($\mu\text{g/kg}$)	ND	ND	1	10	16	4	8
TOTAL PCBS ($\mu\text{g/kg}$)	ND	ND	25	314	435	59	194

Notes:

ND: Not Detected

Source:

PRC, 1994b

TABLE 2-14

**SUMMARY OF PREVIOUS ANALYTICAL RESULTS
SURFICIAL SEDIMENT SAMPLES
SITE 2, WEST BEACH LANDFILL**

METALS DATA

	Sampling Station						
	W1	W2	W3	W4	W5	W6	W7
TOTAL METALS							
Antimony (mg/kg)	ND	ND	ND	0.7	ND	ND	ND
Arsenic (mg/kg)	1.6	1.7	2.5	9.9	11.8	7.1	7.3
Beryllium (mg/kg)	0.2	0.2	0.3	0.9	0.8	0.6	0.5
Cadmium (mg/kg)	0.1	0.2	0.3	1.5	0.5	0.3	0.4
Chromium (mg/kg)	60.5	66.0	71.5	139.7	140.5	100.3	98.7
Copper (mg/kg)	4.3	5.8	9.1	54.0	48.0	25.0	28.7
Lead (mg/kg)	1.9	2.6	6.8	57.7	49.5	18.3	24.3
Mercury (mg/kg)	0.01	0.01	0.04	0.65	0.74	0.25	0.24
Nickel (mg/kg)	22.8	29.5	32.3	96	88.5	59	55
Selenium (mg/kg)	ND	ND	ND	0.3	0.4	0.2	0.2
Silver (mg/kg)	ND	ND	ND	1	0.7	ND	ND
Thallium (mg/kg)	ND	ND	ND	ND	ND	ND	ND
Zinc (mg/kg)	20.8	25	33.5	210	175	96.7	112
TOTAL	112	131	156	572	516	308	327

Notes:

ND: Not Detected

Source:

PRC, 1994b

TABLE 2-15
SUMMARY OF PREVIOUS ANALYTICAL RESULTS
TISSUE SAMPLES
SITE 2, WEST BEACH LANDFILL

		Sampling Station		
	W4	W5	W6	W7
TOTAL PAHS ($\mu\text{g/kg}$)	ND	ND	ND	ND
TOTAL METALS (mg/kg)	131	140	108	108
TOTAL ORGANOTINS ($\mu\text{g/kg}$)	97	ND	ND	67
TOTAL ORGANOCHLORINE PESTICIDES ($\mu\text{g/kg}$)	61	83	ND	ND
TOTAL PCBS ($\mu\text{g/kg}$)	358	426	ND	254

Notes:

ND: Not Detected

Source:

PRC, 1994b

TABLE 2-16
SUMMARY OF PREVIOUS ANALYTICAL RESULTS
TISSUE SAMPLES
SITE 2, WEST BEACH LANDFILL

METALS DATA

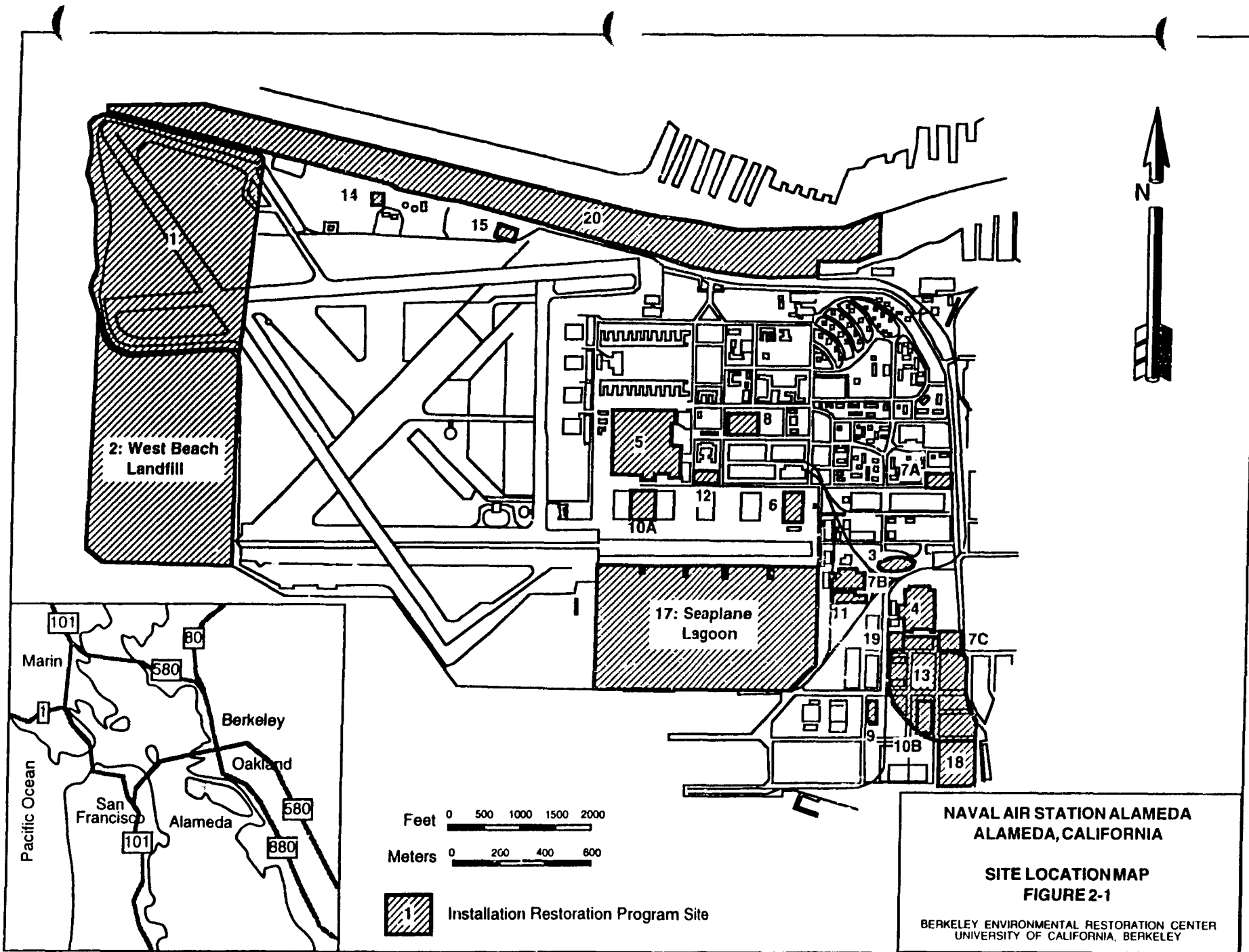
	Sampling Station			
	W4	W5	W6	W7
TOTAL METALS				
Arsenic (mg/kg)	21.2	21.4	20.2	12.5
Copper (mg/kg)	10.3	11.1	15.6	15.0
Lead (mg/kg)	1.8	2.6	1.1	1.2
Mercury (mg/kg)	0.1	0.1	ND	0.1
Nickel (mg/kg)	4.6	6.1	ND	ND
Zinc (mg/kg)	93.3	98.2	70.8	79.3
TOTAL	131	140	108	108

Notes:

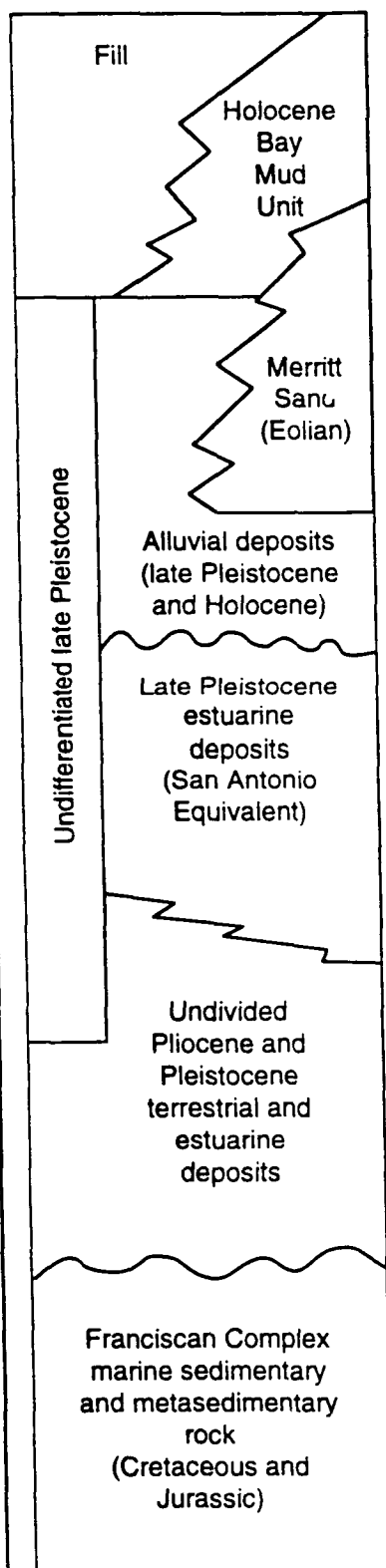
ND: Not Detected

Source:

PRC, 1994b



San Francisco Bay



Artificial Fill:

The fill material in the vicinity of NAS Alameda consists of silty sand to sand with inclusions of clays and/or gravels. The fill consists of dredge spoils from the surrounding San Francisco Bay, the Seaplane Lagoon, and the Oakland Channel. The fill was hydraulically emplaced.

Contact Between Fill and Holocene Bay Mud Unit:

The contact is identified by a lithology change from silty sand to sand to, in certain locations, silty clay to clayey sand with abundant shells or an increased quantity of shell hash material.

Holocene Bay Mud:

The Holocene Bay Mud Unit in the vicinity of NAS Alameda consists of black to gray, clay to silty clay with clayey sand to sands.

Late Pleistocene/Holocene Alluvial Eolian Deposits:

The eolian deposits in the vicinity of NAS Alameda consist of yellow-brown, fine-grained sand to silty sand. The alluvial deposits in the vicinity of NAS Alameda consist of dark olive gray to gray, silty sand to clayey sand to fine-sand with clay stringers.

Contact Between the Late Pleistocene/Holocene Alluvial/Eolian Deposits and Late Pleistocene Estuarine Deposits:

The contact is identified by an unconformity defined by a definite color and lithology change from dark olive gray to gray for the alluvial deposits or yellow-brown silty or clayey sand to sand for the eolian deposits to dark greenish gray to gray, organic silty clay.

Late Pleistocene Estuarine Deposits:

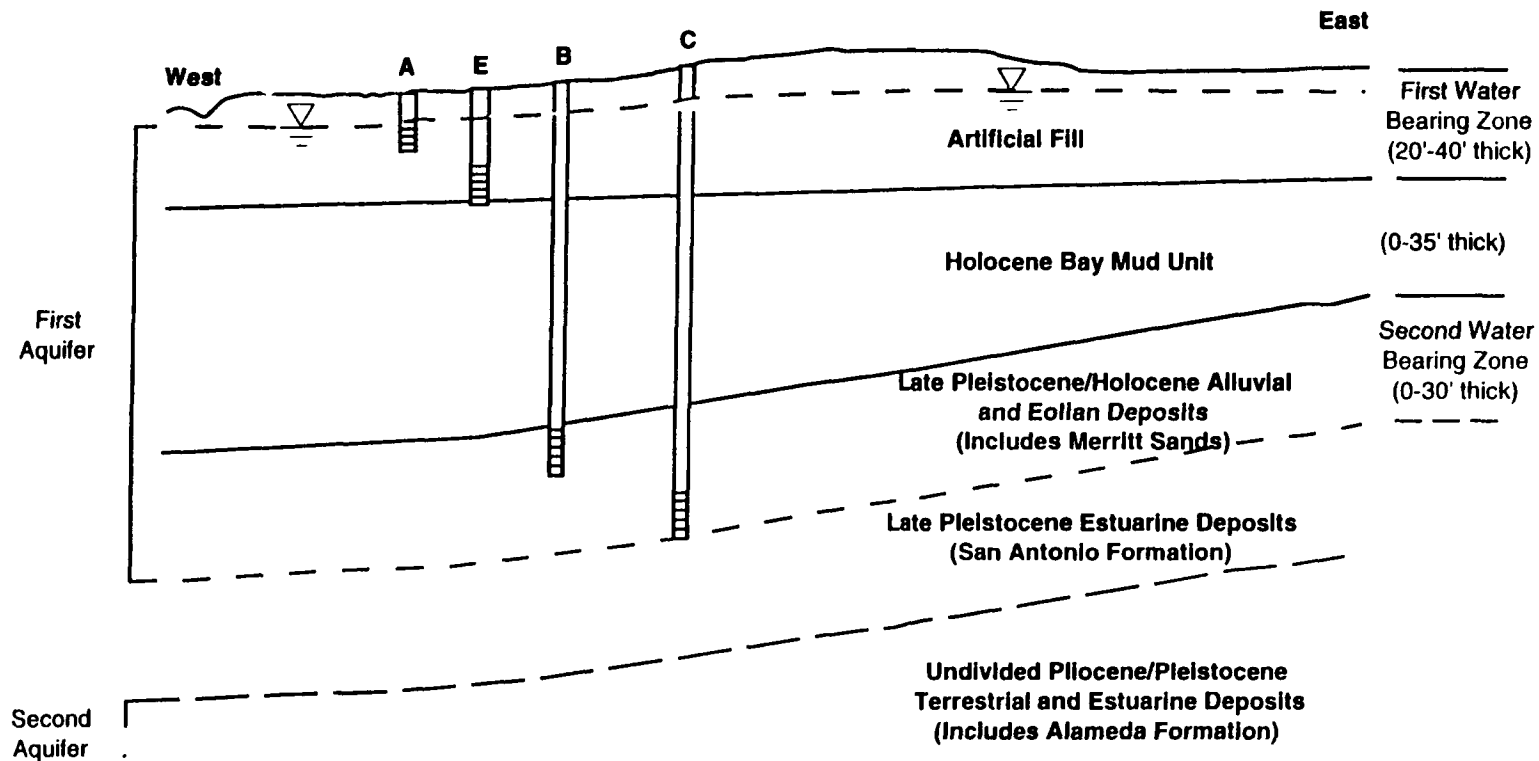
The estuarine deposits in the vicinity of NAS Alameda consist of a dark greenish-gray to gray, very stiff, organic, silty clay.

**NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA**

**IDEALIZED STRATIGRAPHIC COLUMN
FOR ALAMEDA AREA
FIGURE 2-2**

Source: PRC, 1995

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY



- A- Wells completed in the First water-bearing zone at the top of the saturated Artificial Fill
- E- Wells completed in the First water-bearing zone at the base of the Artificial Fill
- B- Wells completed in the Second water bearing zone at the top of the Late Pleistocene/Holocene Alluvial and Eolian Deposits (beneath the Holocene Bay Mud Unit)
- C- Wells completed in the Second water-bearing zone at the base of the Late Pleistocene/Holocene Alluvial and Eolian Deposits above the Late Pleistocene Estuarine Deposits (San Antonio Formation)

Static Water Level

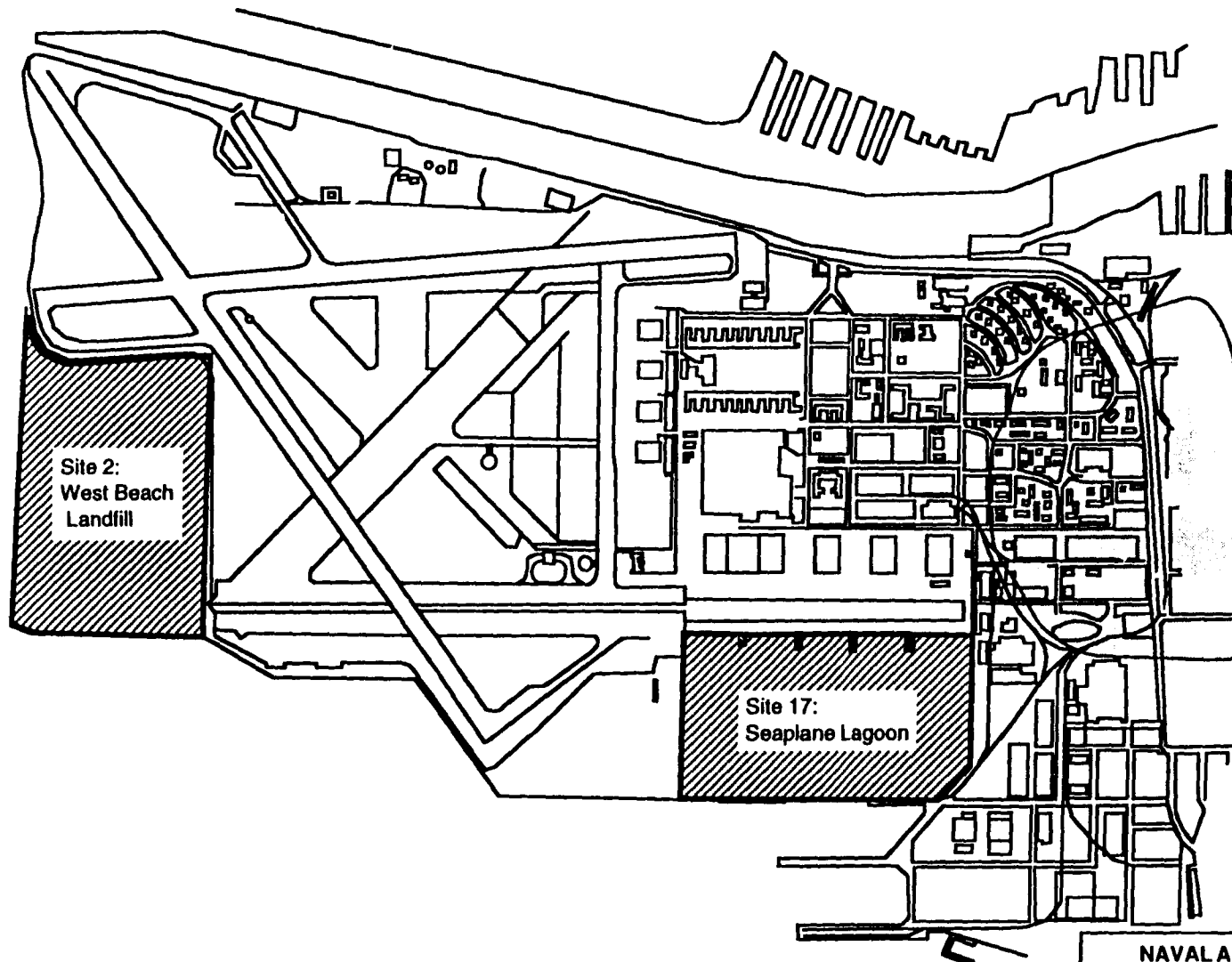
Not to scale

Source: PRC, 1995

NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

SCHEMATIC DIAGRAM OF
FIRST AND SECOND AQUIFERS
FIGURE 2-3

BERKELEY ENVIRONMENTAL RESTORATION CENTER
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Feet 0 500 1000 1500 2000
Meters 0 200 400 600

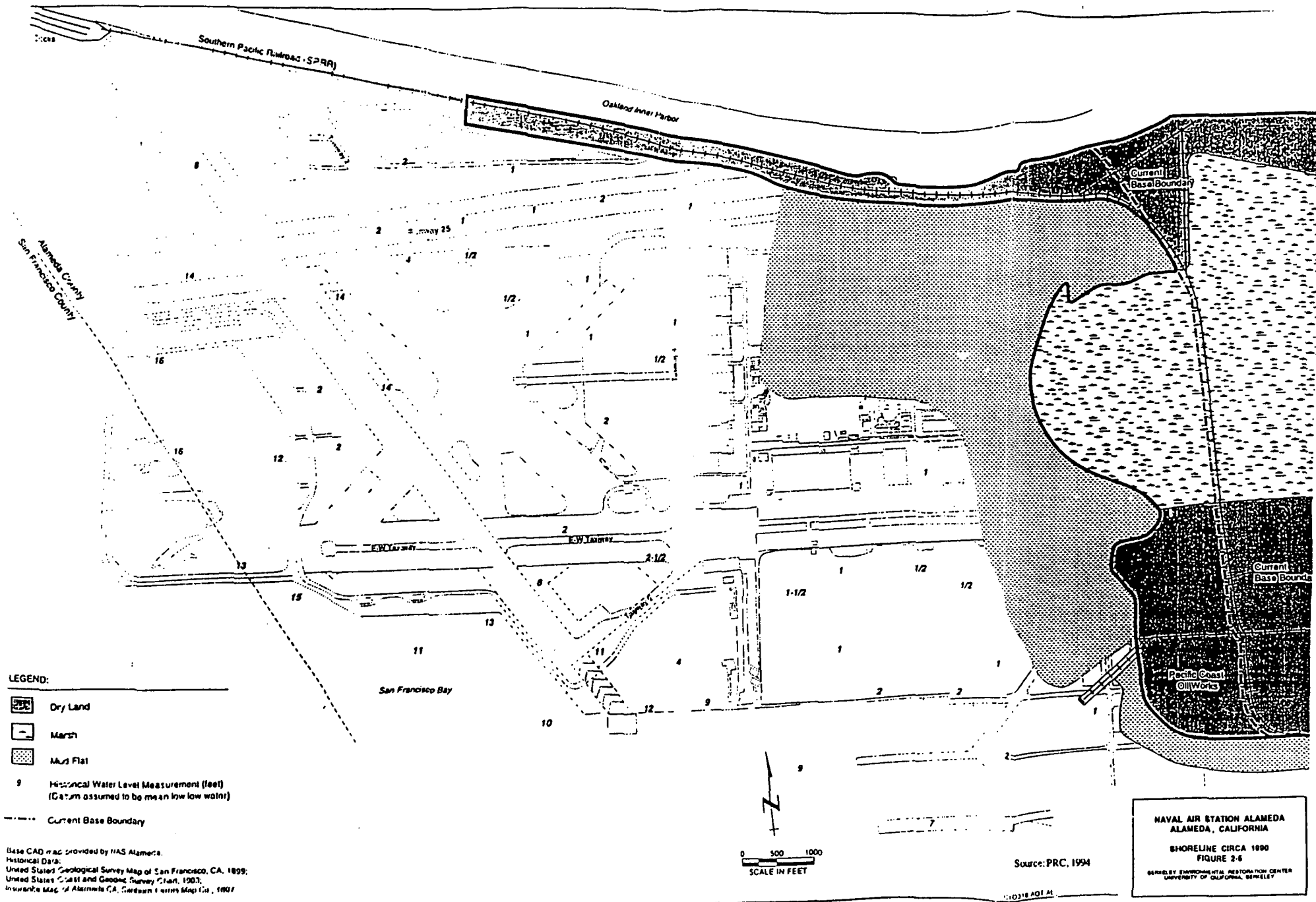


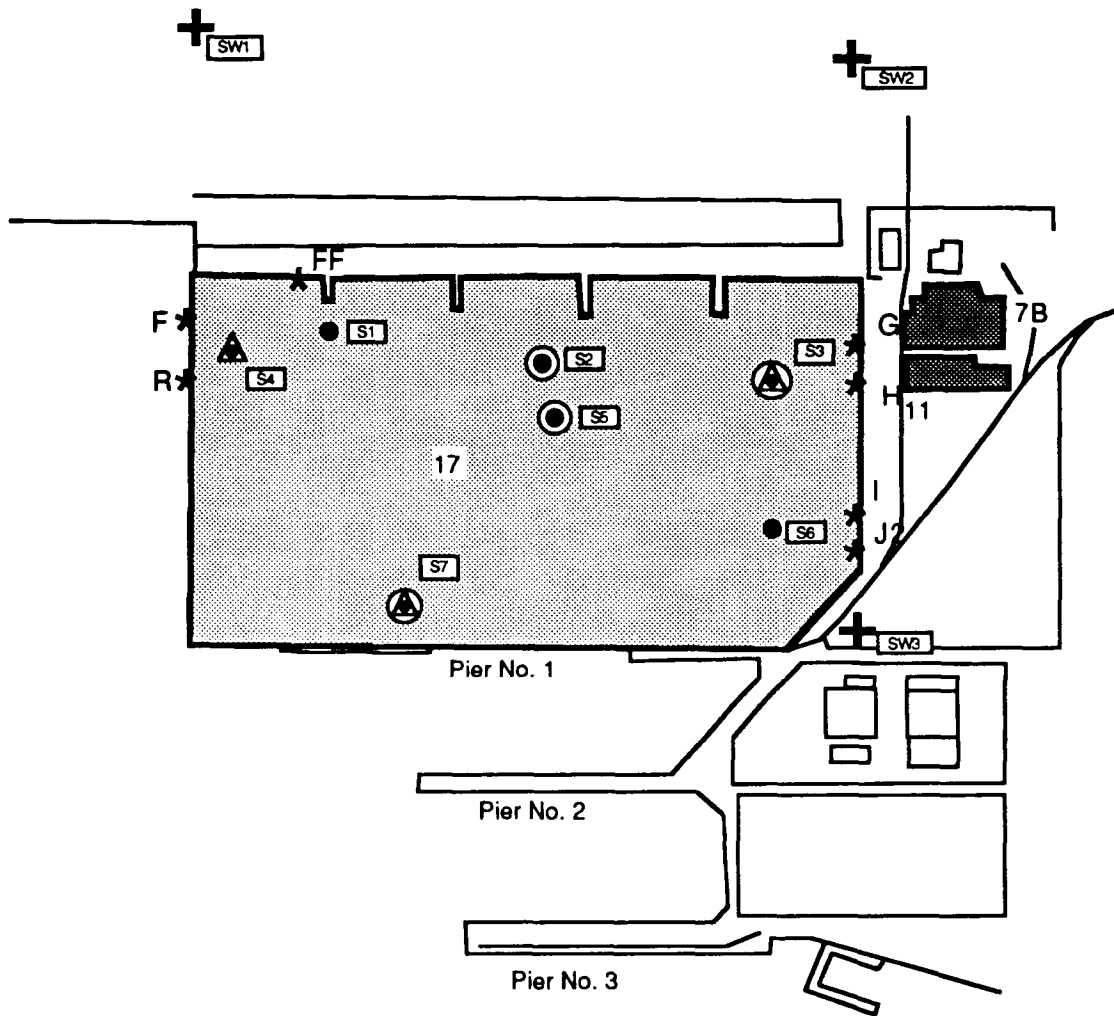
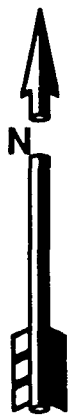
1856 Tidal Flat Area Source: PRC, 1995

NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

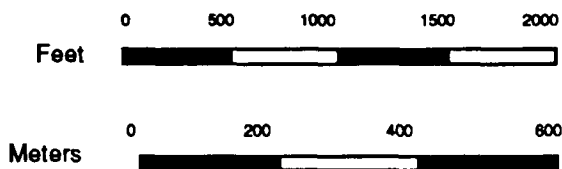
1856 TIDAL FLAT AREA
FIGURE 2-4

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY





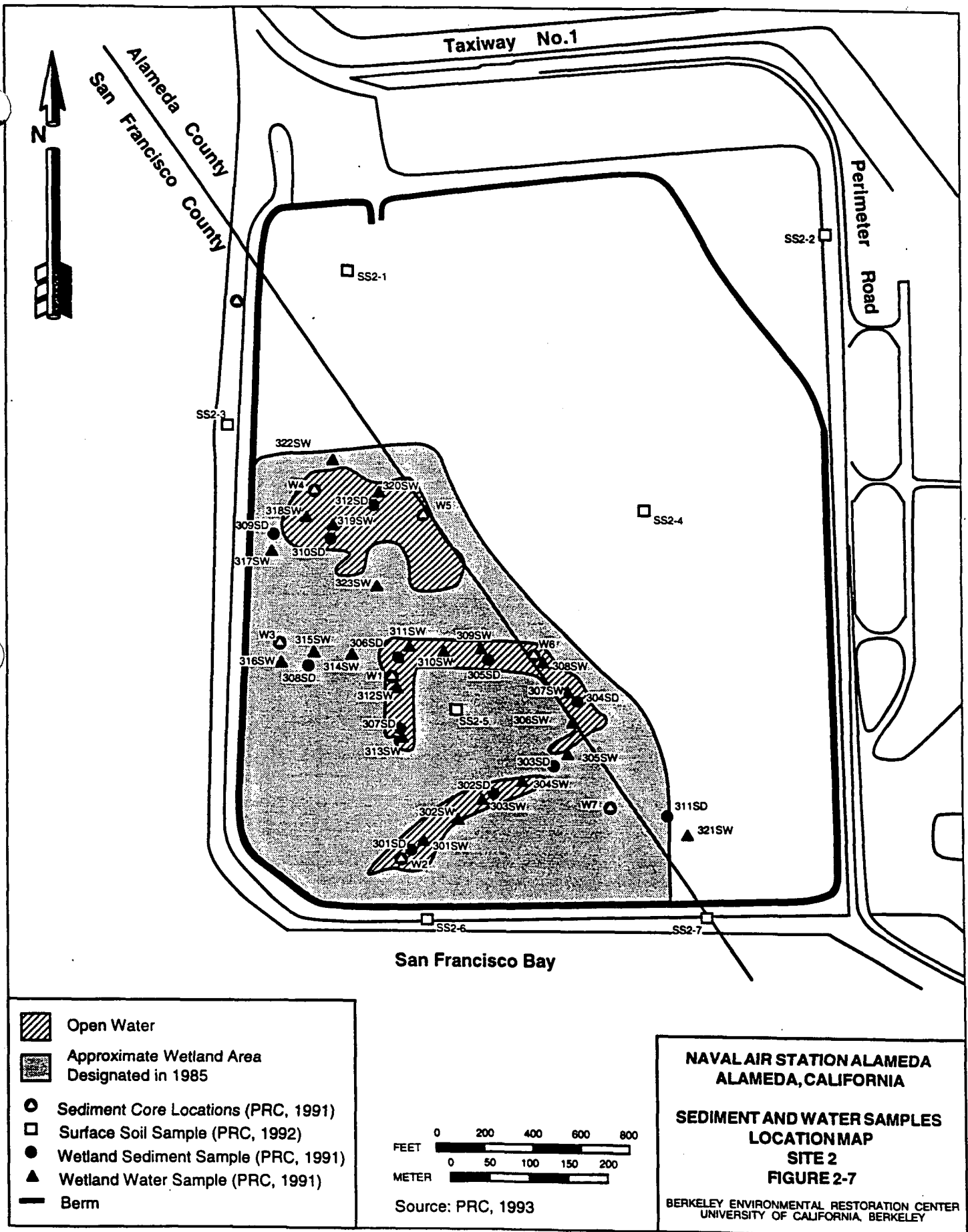
- * Location of Stormwater outfalls (A through J)
- + Location of Stormwater Sample (PRC, 1994)
- Location of Sediment Grab Sample (PRC, 1994)
- △ Location of Sediment Core Sample and Water Sample (PRC, 1994)
- Location of Sample for Bioaccumulation and Benthic Population Studies (PRC, 1994)

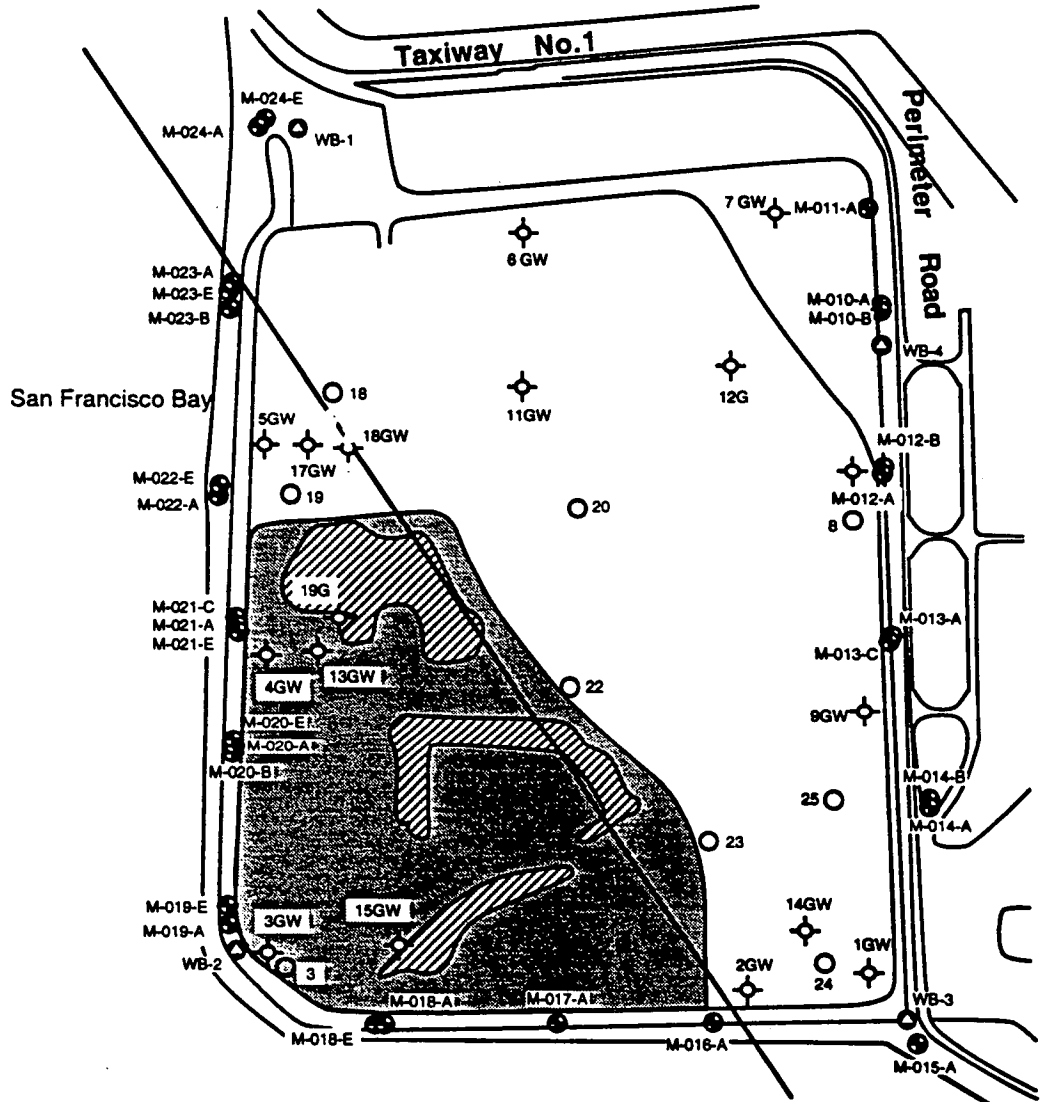








NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

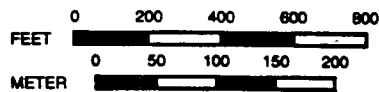
SEAPLANE LAGOON (SITE 17)
FIGURE 2-6

BERKELEY ENVIRONMENTAL RESTORATION CENTER
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-  Open Water
-  Approximate Wetland Area Designated in 1985
-  Boring (Canonie, 1990)
-  Monitoring Well (PRC, 1992)
-  Boring (HLA, 1978)
-  Monitoring Well (E & E, 1983)

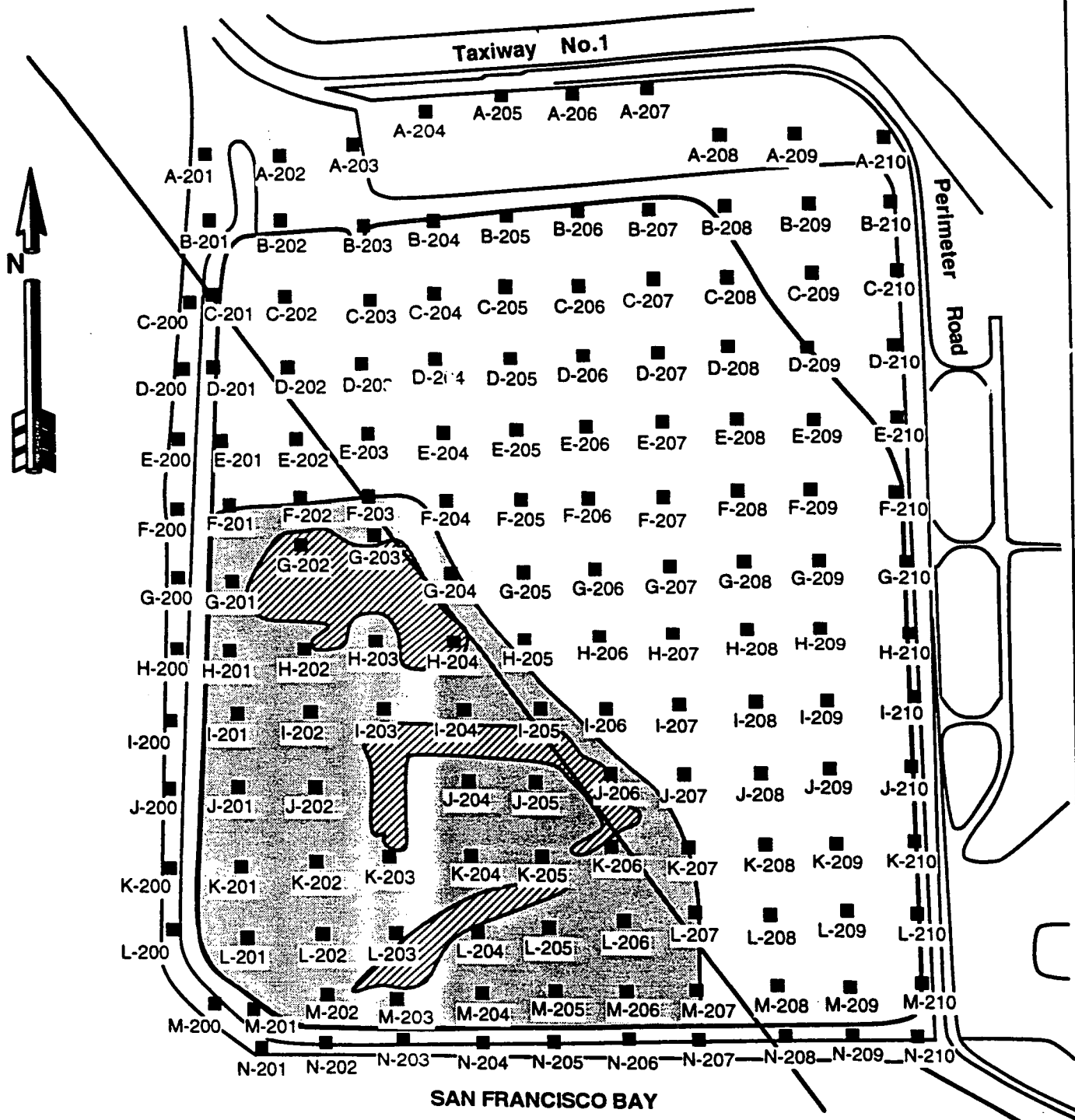


Source: PRC, 1993 & HLA, 1978

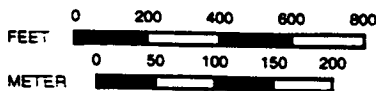
NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

MONITORING WELLS AND BORING LOCATION MAP SITE 2 FIGURE 2-8

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY



- Surface Soil Sample (PRC, 1991)
- Berm
- ▨ Open Water
- ▤ Approximate Wetland Area Designated in 1985

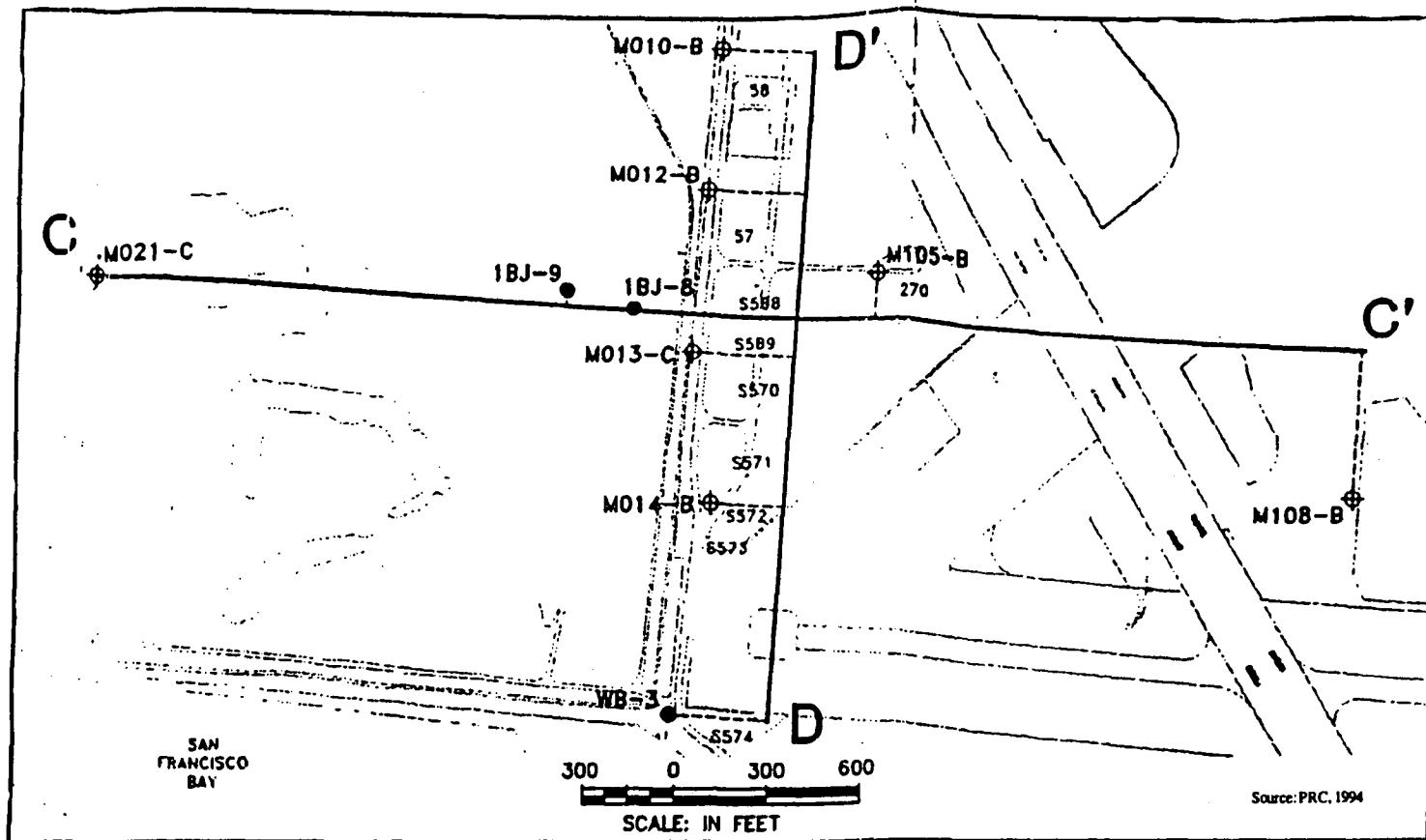


Source: PRC, 1991

NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

SURFACE SOIL SAMPLE
LOCATION MAP
SITE 2
FIGURE 2-9

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY

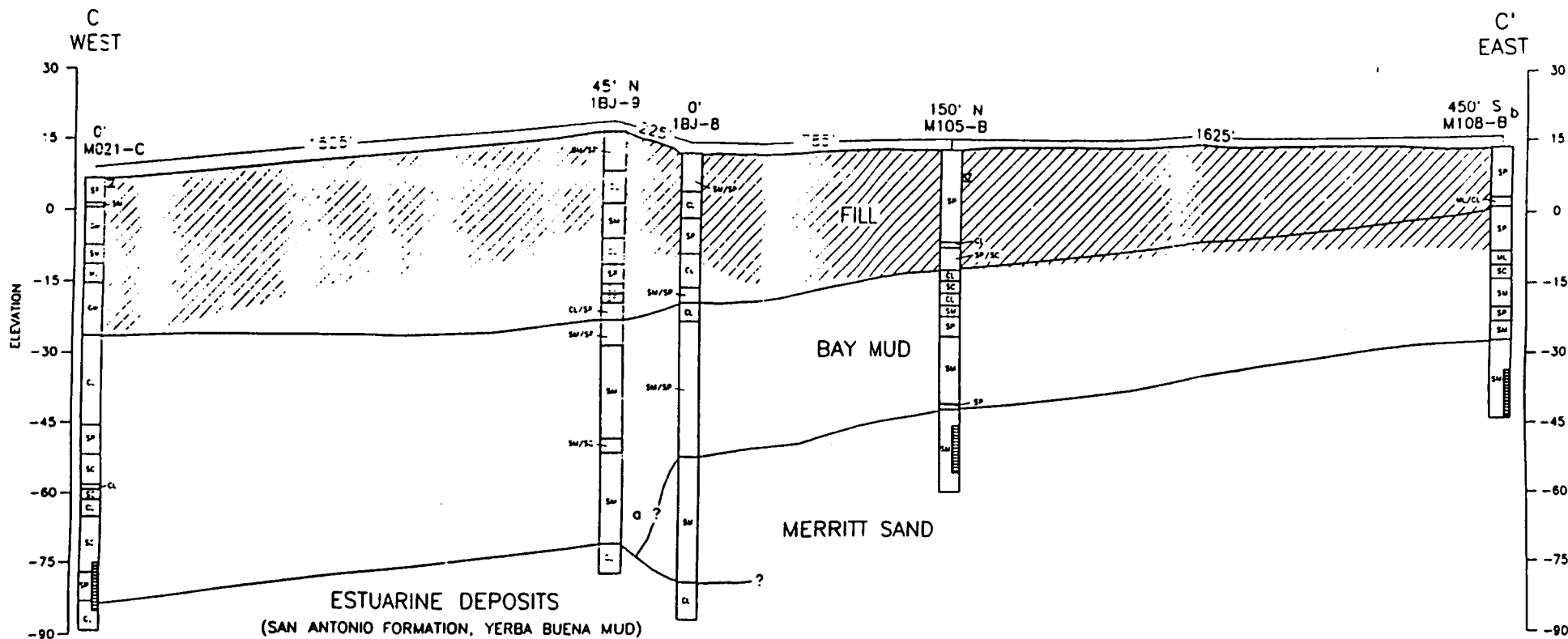


SITE 2

NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

CROSS SECTION
LOCATION MAP
SITE 2
FIGURE 2-10

BERKELEY ENVIRONMENTAL RESTORATION CENTER
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Source: PRC, 1994

NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

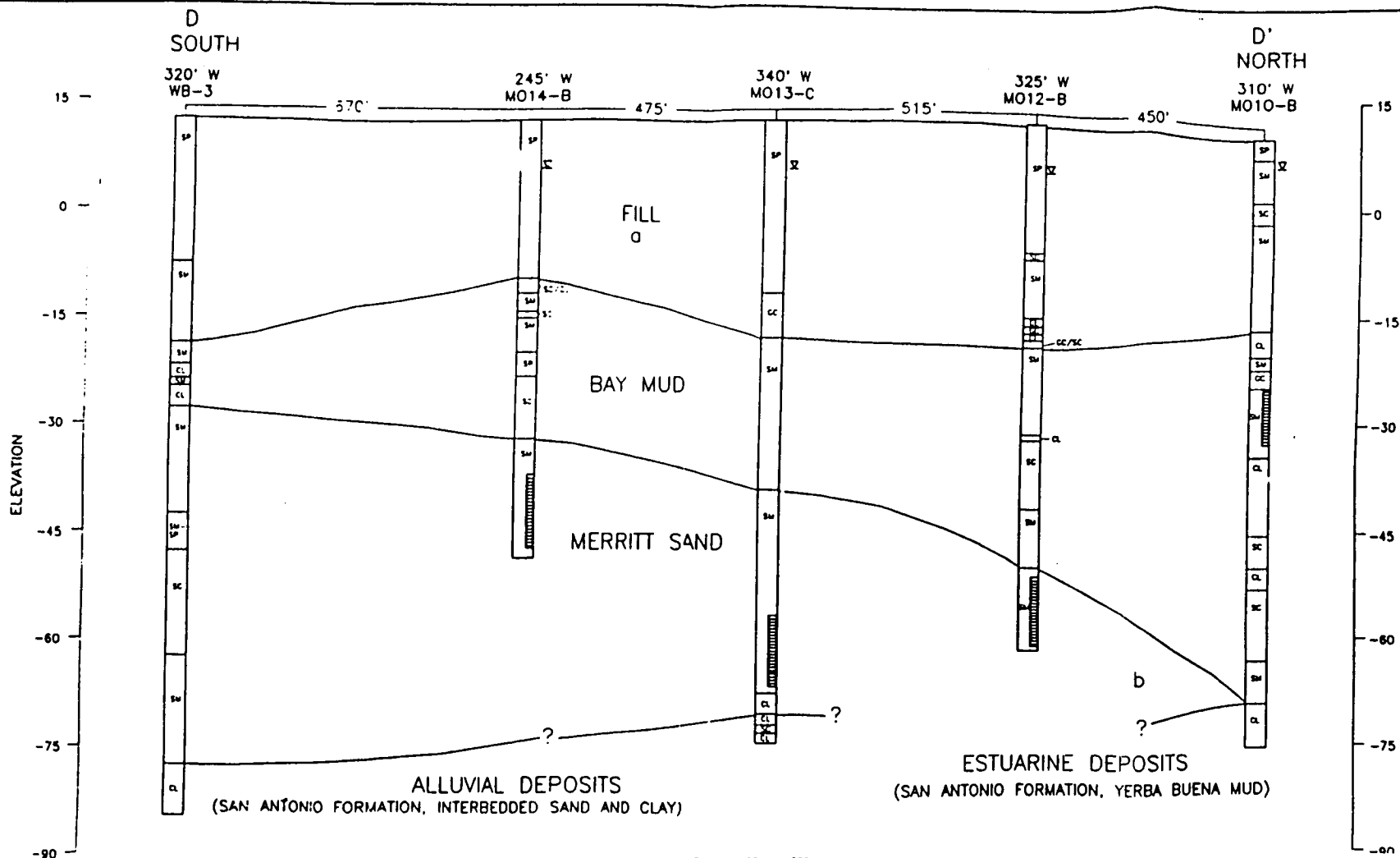
GEOLOGICAL CROSS SECTION
C-C'
SITE 2
FIGURE 2-11

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA BERKELEY

NOTES

1. MERRITT SAND PINCHES OUT BETWEEN BORINGS 18J-8 AND 18J-9 BECAUSE A PALEOCHANNEL ERODED THROUGH THE MERRITT SAND TO THE ESTUARINE DEPOSITS.

2. WATER LEVEL NOT MEASURED BECAUSE OF NESTING WILDLIFE NEAR WELL.



LEGEND

APPROXIMATE LOCATION OF CONTACT BETWEEN LITHOLOGIC UNITS

WATER LEVEL MEASURED JULY 1995

MONITORING WELL SCREENED INTERVAL

SW U.S.C.S. CODE OF BORING IDENTIFICATION

UNDEFINED CORRELATION

DISTANCE BETWEEN WELLS AND BORINGS

DISTANCE AND DIRECTION FROM WELL OR BORING TO CROSS SECTION LINE SHOWN ON FIGURE 1-11

NOTES:

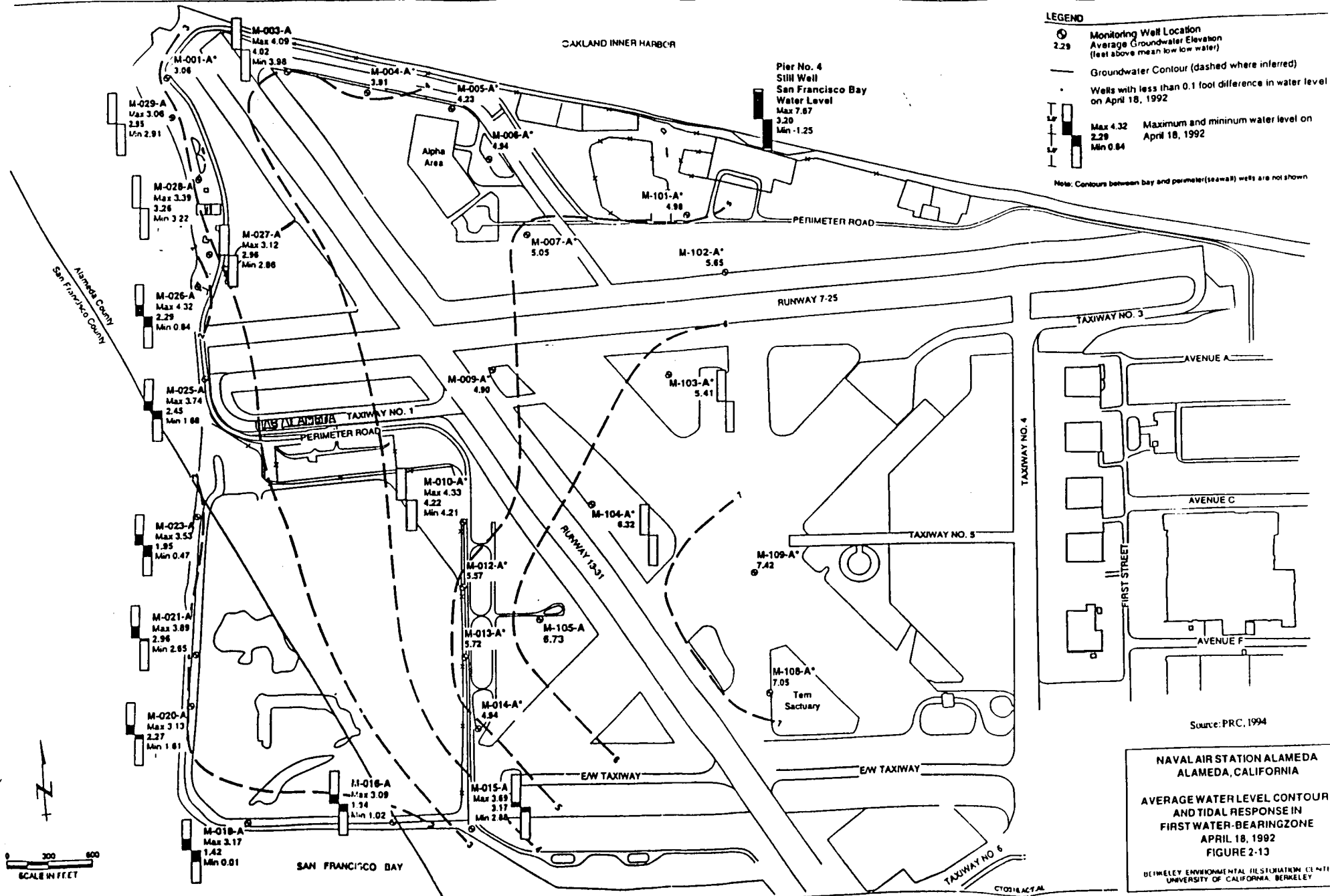
- NO SIGNIFICANT LAYER (5 FEET OR GREATER) OF SILT OR CLAY WAS ENCOUNTERED IN BORINGS ALONG THIS CROSS SECTION, SO THE LOCATION OF THE FIRST WATER-BEARING ZONE IS NOT CLEAR. THE FIRST WATER-BEARING ZONE MAY BE INTERCONNECTED WITH THE SECOND WATER-BEARING ZONE IN THE AREA OF THIS CROSS SECTION.
- MERRITT SAND AND ALLUVIAL DEPOSITS PINCH OUT BETWEEN BORINGS M013-C AND M010-B BECAUSE A "LEACHMERE" ERODED THROUGH THESE DEPOSITS TO THE LITOMINE DEPOSITS.

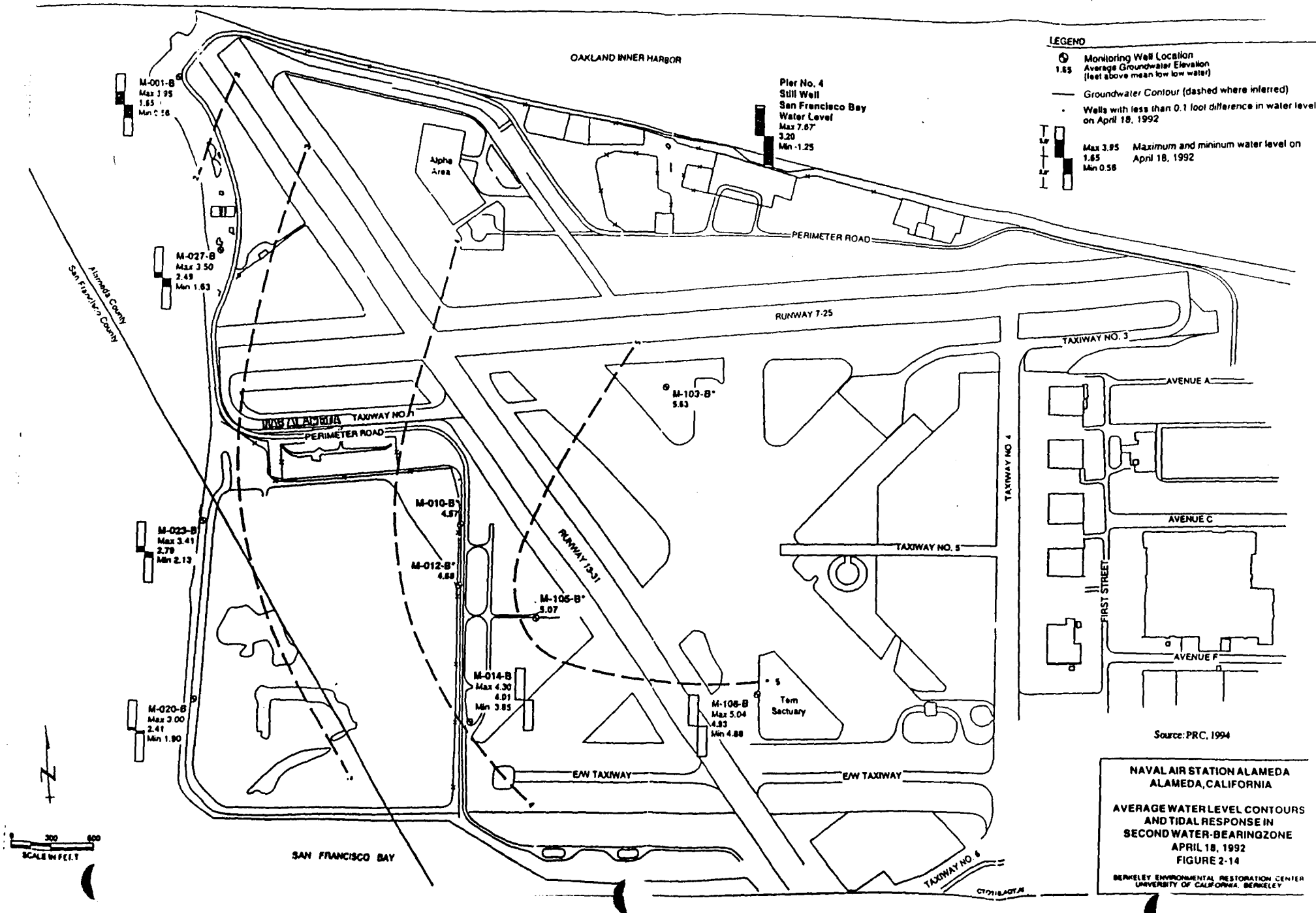
Source: PRC, 1994

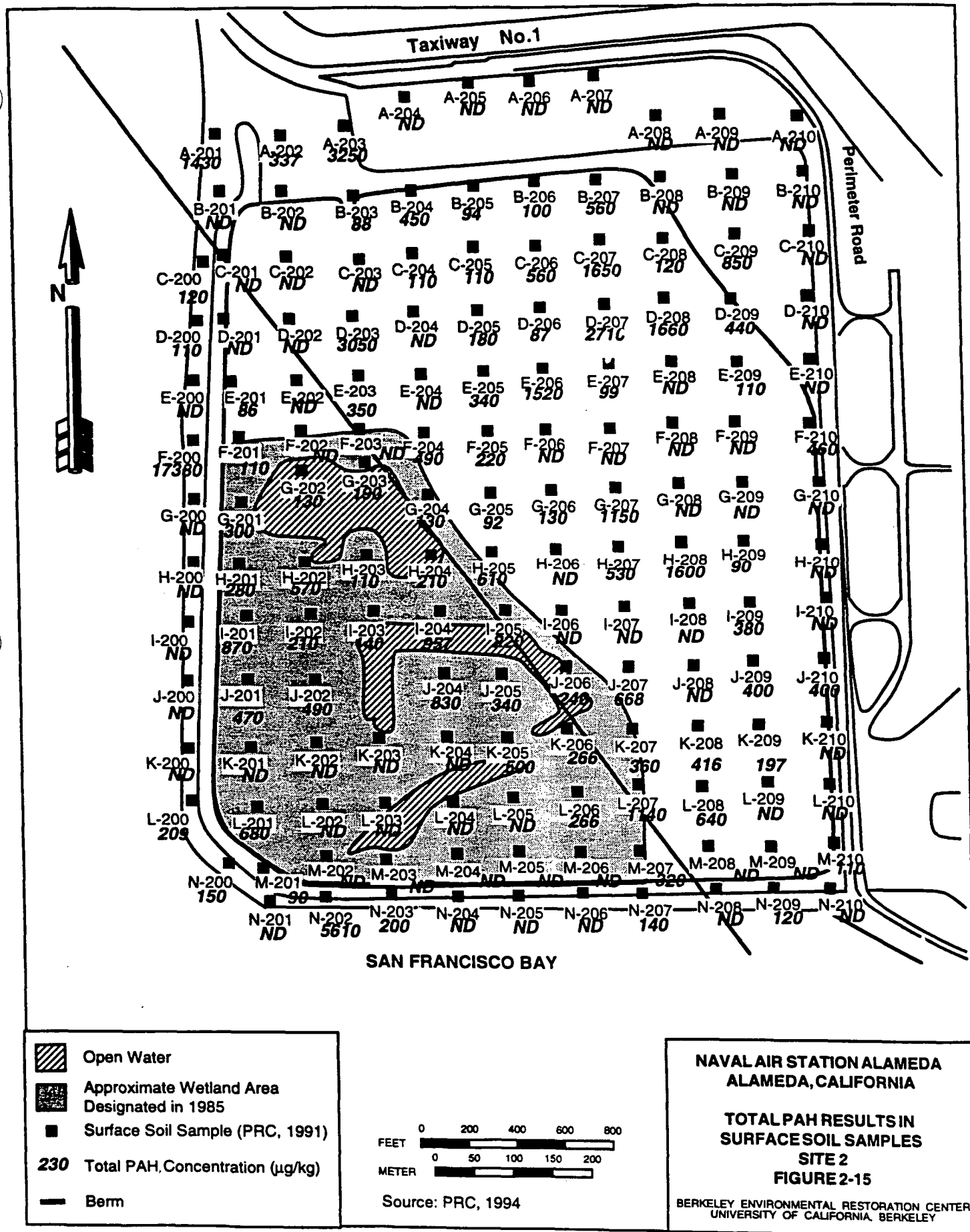
NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

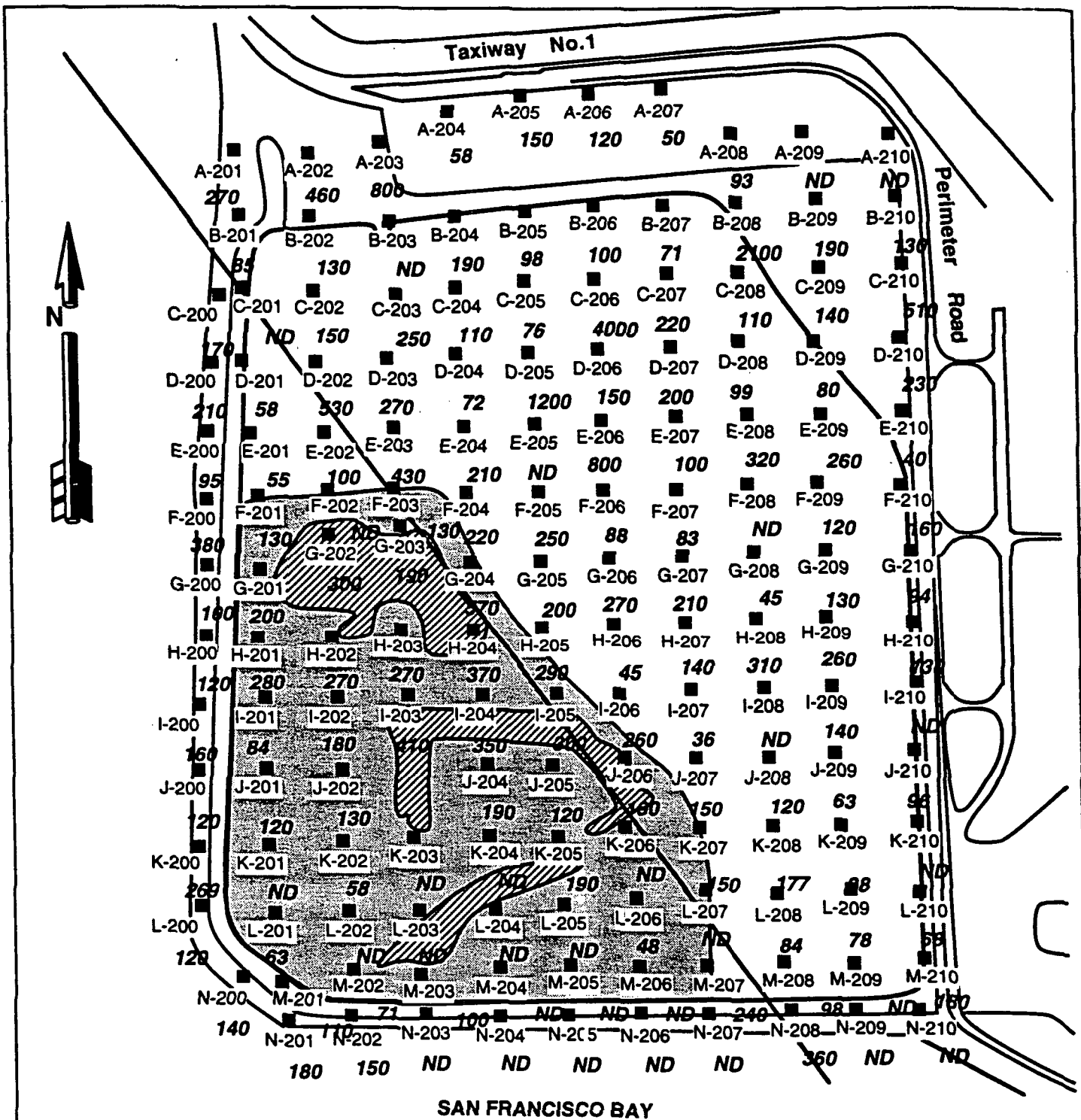
GEOLOGICAL CROSS SECTION
D-D'
SITE 2
FIGURE 2-12

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY





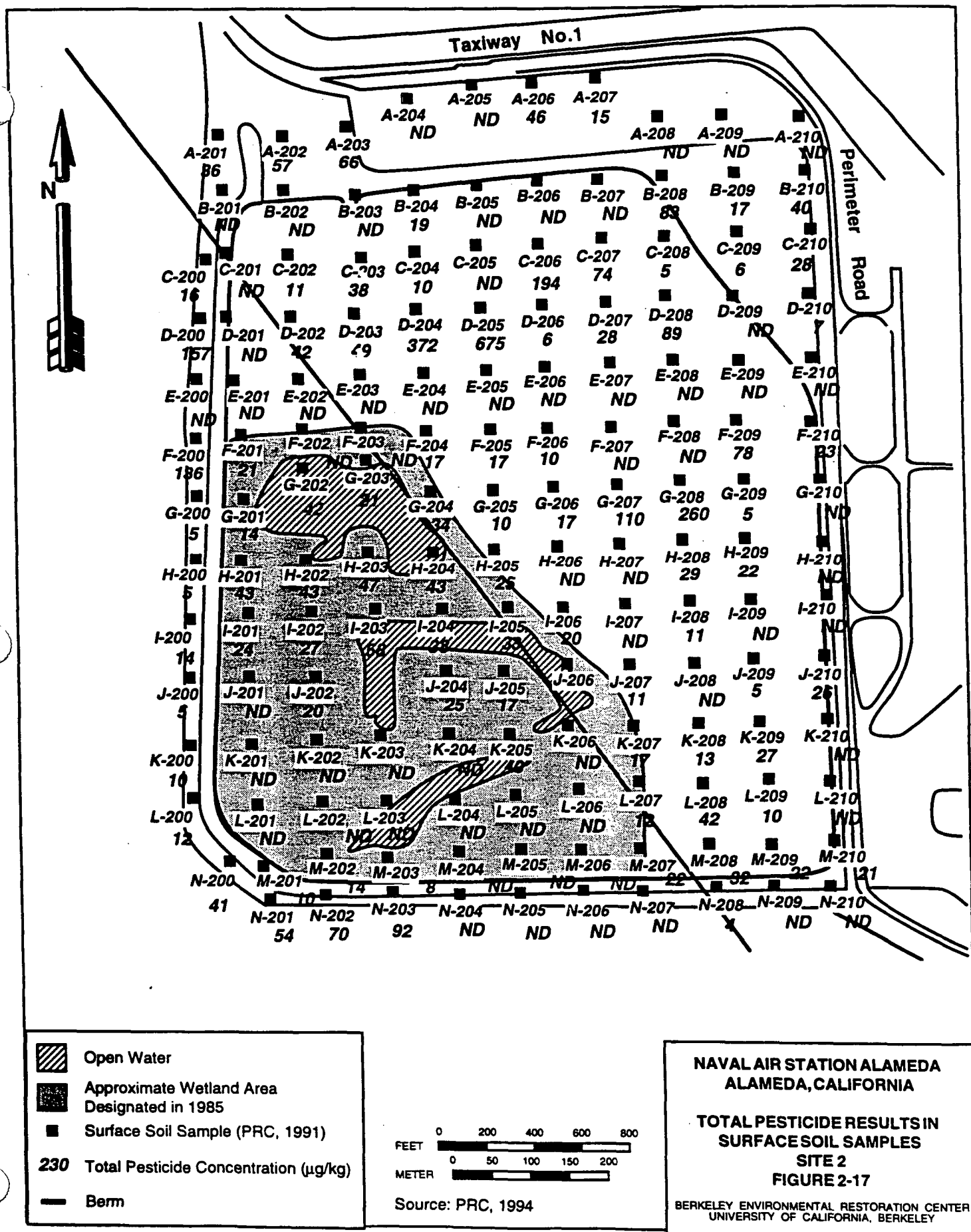




**NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA**

**TOTAL PCB RESULTS IN
SURFACE SOIL SAMPLES
SITE 2
FIGURE 2-16**

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY



3.0 OVERVIEW OF PROPOSED PROJECT FOR INTRINSIC SEDIMENT PROCESSES STUDY

This section of the Work Plan provides an overview of the Berkeley Environmental Restoration Center's approach for the conduct of site characterization and treatability studies for the sediments in the Seaplane Lagoon and in the West Beach Landfill Wetlands area. These studies are in support of the Navy's program to conduct feasibility studies for Site 2 and for Site 17 at NAS Alameda (see Section 1.4). The objectives of this project are as follows:

1. Assessment of chemical migration pathways and toxicity in sediments
2. Evaluation of the time-scale for intrinsic remediation processes
3. Evaluation of selected issues associated with remedial strategies

At the time of the preparation of the work plan, the risks associated with specific chemicals present in lagoon or wetland sediments have not been determined by the Navy. Based on data from previous investigations, the chemicals of potential concern as identified by the Navy are metals, PCBs and PAHs; these chemicals also have been of concern in sediments at other sites. While there is literature that generally describes the behavior of these chemicals in sediments, the environmental settings of the Seaplane Lagoon and the West Beach Landfill Wetlands are unique in terms of depositional history and chemical constituent distribution compared to the literature information. Therefore, a site-specific understanding of how these chemicals are behaving, or may behave in the future, is important for selecting remedial actions - especially if an option that includes leaving sediments in place is to be considered.

A number of studies will be conducted by BERC to address topics of geochemistry, toxicity, bioavailability, water flow, and the transformation of chemicals in sediments. A major focus of the studies is to elucidate the processes that currently control the site-specific transformation and transport of chemicals in undisturbed sediment systems. These studies then will help define the extent to which "intrinsic processes" in the undisturbed sediments control the toxicity, availability, or concentrations of chemicals in exposure pathways. Toxicity and bioaccumulation tests will also be conducted, with these empirical data then related to the composition and geochemistry of the pore water sediment. Knowledge of the geochemistry is also important for an evaluation of the potential for release of chemicals should the sediment be disturbed. Other studies related to methane generation in sediment and water flow are important for their implications to remedial options such as capping. This information will be contained in individual technical reports, and then summarized and integrated in a final report to the Navy.

The studies by BERC will employ a limited sampling effort focused on what is considered to be the more contaminated areas of the sites. The individual studies will then test and apply the methods to accomplish the above objectives at these locations, with some emphasis on how conditions and processes may vary in the sediment profile. As required, the methods developed and applied in this project can be used later in an expanded investigation to further define the lateral and vertical site characteristics for decisions regarding risk and remedial options, including sediment removal.

3.1 BACKGROUND FOR APPROACH

The chemicals in sediments are present through association with particulate matter that settle out from the overlying water column. In the marine systems, the dynamics of particle movement are controlled by fresh water inflow, tidal currents, wind-induced currents, and storms. For many parts of a marine system, there is a net deposition of newer sediments which covers older sediments and the previously co-deposited chemicals. The sediments and the chemical constituents

then undergo microbial and chemical alterations that are a function of nutrient availability and diffusion processes in the sediment.

Within the sediment bed, there is a sequence of layers, each having unique microbial communities and associated chemistries. The uppermost layers are dominated by aerobic microbial processes in which oxygen is utilized to oxidize organic matter (natural or anthropogenic). The progressively deeper sediment layers are oxygen depleted and are characterized by organisms that utilize nitrate, then iron and manganese, as electron acceptors to effect oxidation of the organic material. Deeper layers utilize sulfate as an electron acceptor, resulting in production of sulfides; even deeper layers result in fermentation/methanogenesis where organic materials are converted to organic acids, carbon dioxide, and methane.

These strata and their attendant microbial communities control the oxidation/reduction chemistry, the resulting speciation of metals in the layers, and the dominant biochemical pathways that are available for transforming the chemical constituents in the respective layers. The distances over which these changes occur in the very fine, organic-rich sediments are potentially very small, on the order of a few centimeters in going from the oxygenated layer to the sulfate-reducing layer. The chemical form of the trace metals is also associated with the oxidation/reduction potential of the layers. For example, in the more oxic layers the metals may be complexed in solution by soluble organic or inorganic ligands or sorbed to iron and manganese oxides; whereas, in deeper sediments the absence of these oxides and the presence of sulfate reducing systems results in the formation of insoluble metal sulfides. As a result, the composition of sediment and of the interstitial water (commonly called pore water) is expected to vary with sediment depth.

The above sequence in sediment chemistry is expected to be generally operative even in the presence of the past chemical releases. As shown in Section 2, elevated levels of metals and selected organic constituents are present in the lagoon and wetlands sediments, with the highest concentrations in the lagoon being located near the outfalls. The amount of naturally occurring organic material compared to the organic substances from Navy sources (fuel releases, lubricant hydrocarbons, etc.) is not known; similarly, the contribution of Navy sources to the total metal loading in sediments is not known. The ecological effects of the releases is also undetermined. The more elevated concentrations of metals and organic constituents are located in the deeper sediments, where anaerobic processes occur. These processes are generally considered to be slower than aerobic processes, but may be important in reducing the chlorine content of synthetic chlorinated organic chemicals, such as PCBs, that are highly resistant to oxidation in surface soils and waters.

While the lagoon and wetlands are physically dissimilar, the same general transport and microbial processes are expected to control the fate, transport, and toxicity of chemicals present. The seaplane lagoon sediments are perennially saturated, and contain organic and inorganic chemicals that were washed from NAS Alameda storm drains and then deposited in sediments. The West Beach Landfill Wetlands, by comparison, are episodically flooded by season and possibly by tidal action, with some areas perennially flooded as daylighted groundwater. Chemicals present in the wetlands are nominally the same types as have been discharged into the lagoon, but lower concentrations are likely present in the wetlands itself. The major differences in the two sites are the wet/dry cycling in sediments in the wetlands and the uncertainty of chemical movement out of the wetlands during these cycles.

3.2 PROJECT APPROACH

The proposed treatability study program consists of a number of tasks to apply innovative methods to assess the speciation, toxicity, and natural (intrinsic) processes that are occurring in the lagoon and wetlands sediments. Each task will be a study representing a focused disciplinary topic, from which specific data or information will be used to complement other studies with an overall

accomplishment of project objectives. The individual tasks to be conducted for the Seaplane Lagoon and for the West Beach Landfill Wetlands are presented in flow chart format in Figure 3-1 and Figure 3-2, respectively. The objectives of the tasks to be conducted are discussed in the sections below. The sampling strategy is discussed in Section 4, and the specific methods and analyses to be used are described in Section 5.

3.3 PHYSICAL CHARACTERIZATION OF SEDIMENTS

The stratigraphy of the lagoon sediments, Bay Mud, and Merritt Sands will be investigated during the initial task, and properties of the sediment layer will be measured in a later task (see Transport Processes). PRC has previously determined the particle size fractions of sediment and the depth and diversity of benthic organisms in the lagoon. These data will be compared to BERC data for specific locations and samples to assess the representativeness of the BERC data. BERC understands that PRC will be collecting sediment samples from corings in the Seaplane Lagoon, and PRC will have these samples analyzed to assess the lateral and vertical distribution and bulk (or total) concentrations of metals and selected organic constituents. PRC will also be collecting surface soil samples and water samples in selected areas of the wetlands area to supplement data from earlier PRC investigations.

Acoustic imaging on transects across the Seaplane Lagoon will be conducted to measure the depth to sediment and the depth of sedimented material overlying Bay Mud in the lagoon. This information is important for evaluating the mass of sediment requiring treatment should an invasive or in situ remedial alternative be considered. It is also expected that this technique will provide information on the depth of Bay Mud and the depth to the Merritt Sands under the lagoon. These data will also be used to assess the presence of bay mud as a barrier to water exchange between the lagoon sediments and Merritt Sands formation, and guide the conduct of the Transport Processes task. The preliminary results of the acoustic imaging study will be shared to assist in PRC's deeper boring program.

Acoustic imaging will also be conducted along the western and southern edges of the seawall around the wetlands to determine the respective depths to sediment, Bay Mud, and the Merritt Sands in this area, and the geometries of materials in the saturated zone beneath the seawall. This information is important for evaluations of water transport into the wetlands under current conditions and for possible remediation scenarios.

3.4 CHEMICAL CHARACTERIZATION OF SEDIMENT AND PORE WATER

Ecological exposure evaluations typically consider the contact of benthic organisms with both pore water and sediment. The two media are usually considered to be in equilibrium. This task will characterize the chemical constituents present in the pore water and the sediments and utilize geochemical models to better understand the potential for chemical changes in pore water chemistry and toxicity. Several studies using sediment cores from the lagoon and from the perennially ponded areas of the wetlands will investigate the chemical speciation and equilibrium of metals in the pore water and sediment. This information is important for understanding the mobility of metals in the sediments, their potential for toxicity, and how these constituents will behave in remedial actions involving sediment management (that is, excavation and land disposal, in situ or ex situ treatment, etc.). Analysis of organic constituents in sediments will be performed as part of the intrinsic transformation table.

In one set of studies, soil cores from approximately 50 cm depth will be analyzed to characterize the constituents present in pore water and in sediment solids. (For this study, chemicals dissolved in pore water will be operationally defined as those chemicals in water that pass through a 0.45 micron filter.) The pore water for these studies will be collected with a device that squeezes pore

water from discrete layers of the sediment core. The pore water samples from each depth segment will be analyzed for the following constituents:

- Anions: chloride, fluoride, nitrite, nitrate, sulfate, and phosphate
- Trace metals: cadmium, copper, chromium, mercury, nickel, lead, and zinc
- Major elements: aluminum, calcium, iron, sodium, magnesium, manganese, silica, and sulfur

In a more shallow sediment interval of 10 to 20 cm, the redox chemistry of pore water in a soil core will be analyzed in situ using a microelectrode system. Dissolved iron, manganese, oxygen, and sulfide will be measured. These data will provide an accurate description of the pore water chemistry within narrow intervals in the near surface sediment zone where benthic organisms are present and the immediate exposure pathways are located, and where oxidation reactions transform organic and inorganic chemicals. These data also will be used in geochemical computer models to simulate the behavior of metals constituents in the pore water/sediment systems in the lagoon and saturated areas of the wetlands, and how the dissolved metal concentrations may change under natural and "disturbed" sediment conditions.

The sediment samples from several depths in the 50 cm core will be analyzed to determine changes in trace metal composition and mineralogy with sample depth. Sediment metals concentrations and mineralogy will first be measured to evaluate any major changes in sediment composition as a function of depth. The metals concentrations will be compared with the more extensive metals database compiled by PRC to identify the samples that are representative of sediment conditions in the lagoon. For samples judged representative of anoxic and oxic environments, the speciation of cadmium, copper, chromium, nickel, lead and zinc on sediment solids will then be determined using x-ray absorption spectroscopy to determine their oxidation state(s) and presence of the metals as the sulfide, oxide, or other solid phase states.

3.5 TOXICITY OF PORE WATER AND AT SEDIMENT/WATER INTERFACE

As noted above, the interstitial (pore) water present in sediments is considered a major exposure pathway for benthic organisms, with the chemicals distributed among sediment, pore water, and organisms. This task will evaluate the toxicity of the pore water, and subsequently toxicity identification evaluation (TIE) will be performed to assign the chemical(s) responsible for the measured toxicity. The toxicity to the selected organisms will also be evaluated at the sediment/surface water interface to assess the role of sediments in possible toxicological effects.

Toxicity tests will be run on sediment pore water samples from the lagoon and from the wetlands sediments using a developmental (growth) test and a survival test. The growth test will be an echinoderm 72-hour embryo development test. The survival test will be a amphipod 10-day survival test. The tests will follow published procedures which are described in more detail in Section 5 and in the Sampling Analysis Plan (SAP).

Pore water samples showing toxicity will be analyzed by TIE procedures to identify the chemicals responsible for the observed toxicity. Because the pore water may contain a number of dissolved inorganic/metal and organic chemicals, a series of chemical separations on pore waters will be conducted with toxicity tests run on the water fractions. These separations and analyses will initially identify inorganic constituents, including naturally occurring species such as ammonia and sulfides, and then proceed to organic constituents as testing indicates toxicity still persists. The TIE procedures will follow published methods and are also described in Section 5 and in the SAP.

Following these assessments of pore water toxicity, the toxicity at the water/surface sediment interface to the same organisms will be tested using surface sediment cores from the lagoon. These tests will then allow an evaluation of whether exposure to toxic constituents in lagoon sediments occurs through exposure to pore water or by sediment contact. The toxicity of surface sediments in the wetlands will not be tested because the chemical composition of the wetlands sediments is not characterized sufficiently to warrant both pore water and sediment/water interface studies.

The toxicity of core segments from deeper in the lagoon sediment profile will also be tested using the sediment/water toxicity system above. These data are important for assessing the intrinsic toxicity of the resulting "new" sediment surface should the overlying sediment be excavated as part of a remediation alternative or to improve the recreational use of the lagoon. As discussed in Section 5.7.2, the toxicity to the same organisms will also be tested using a simulated disturbance scenario as would occur during the aeration and mixing of sediments during excavation of lagoon sediments.

3.6 BIOAVAILABILITY EVALUATION

The bioavailability of organic constituents is a major concern for toxicity to aquatic species as well as for potential bioaccumulation in the ecological and the human food chain. There is, at present, no established test for directly measuring the bioavailability and uptake of chemicals from soils or sediment. Determining bioavailability is complicated because the uptake process involves the rates at which the chemicals are extracted from the sediment/soil and the equilibrium concentrations of the chemical among sediment, water, and organisms. For this characterization study, the bioavailability of chemicals in sediment will be assessed using two approaches. One approach will use an EPA test in which a clam commonly found in San Francisco Bay will be exposed to site sediment for 28-days and the clam tissue will be analyzed for selected organic constituents.

A second approach will use an innovative method where digestive juices from a marine worm will be mixed with site sediments, and the concentrations of organic constituents (PCBs, DDT, and PAHs) present in the extracts will be measured. Previous work has shown that this method has significant merits because it mimics actual sediment/digestive fluid interactions that cannot be included using synthetic extraction fluids or with the kinetic limitations of chemical desorption and uptake by selected organisms. Because the data will be collected in the context of a screening program to demonstrate the use of the bioavailability test, there are no criteria for comparing these results with regulatory guidelines. However, the data will be used with other data collected by the Co-Principal Investigator in previous studies to better establish the method as a meaningful approach to measuring bioavailability of chemicals in sediments.

For use in the modeling of sediments and complementary to the toxicity/TIE efforts above, equilibrium partitioning of organic chemicals between the sediment particulate and pore water will be evaluated for use in the sediment modeling program. This evaluation of equilibrium will not require specific laboratory studies, but will use measured environmental parameters and chemical uncertainties in the property data from the scientific literature to estimate the magnitude and uncertainties in the partitioning process.

3.7 TRANSPORT PROCESSES ASSESSMENT

Understanding of water exchange between water-bearing zones and the associated chemical transport processes is critical to estimate exposure pathways and the ultimate fate of chemicals in the lagoon and wetlands ecosystems. Data for sediment properties in the lagoon are also important for evaluating the potential for future consolidation of lagoon sediment under natural or remediation conditions (such as capping). BERC will use both empirical measurements and simple analytical models that use location-specific parameters. The data for evaluating chemical transport in sediments will be obtained from measurements on sediment cores. Samples from sediment and

Bay Mud strata in the lagoon will be collected to a depth of 9 feet below the sediment surface. This sampling strategy may be changed if acoustic imaging shows that these strata are more shallow.

The lead-210 isotope profile will be used to assess the deposition time periods and patterns of sediment strata in the lagoon. This radioisotope is an eventual decay product of naturally-occurring radium and is deposited from atmospheric sources; other isotopes may also be used if the lead-210 data show that radium-containing materials (possibly from paint or luminescent dials) are present in the lagoon or wetlands areas (see Section 5). With a relatively short half-life, the lead-210 isotope is useful for estimating the time period when the sediment was deposited. These data will be used with the PCB congener and PAH distribution data (see below) to evaluate the transformation rates of chemicals in the sediment strata and the deposition periods when metals were released through storm drains into the Seaplane Lagoon. A lead-210 isotope profile will not be established for the Wetlands sediments because sediment deposition is not considered to be an important source of chemicals in this area.

The potential for water transport through lagoon sediments will be evaluated by measurements of sediment properties. Specifically, the sediment density, porosity, and compressibility will be measured for at least three intervals in sediment cores; the compressibility data will be used to estimate the hydraulic conductivity in the sediment intervals. The acoustic imaging results will also be used to evaluate water interchange between the Merritt Sands and lagoon sediments. If communication between the two stratigraphic zones is evident, piezometers may be installed in the lagoon in a second phase to better evaluate hydraulic gradients in the sediment. These data will be used to calculate the potential for an upward gradient into the lagoon. These data will also be used to assess water and chemical transport in the lagoon sediments.

Evaluation of water movement and exchange in the West Beach Landfill, the adjoining wetlands, and the bay has been historically uncertain because of the expected heterogeneous character of the fill and the possible localized, but highly transmissive, discontinuities in the seawall and levees that define these areas. The possibility of chemical transport from the landfill and wetlands will be assessed in several focused studies. In the first study, three piezometers will be installed between the landfill and the wetlands, and the potential effect of tidal influence monitored by performing slug tests and by comparing water levels in the landfill piezometers with data from monitoring wells in the surrounding area during a maximum tide cycle. Shallow piezometers can be installed to determine whether the tidal fluctuations in the bay cause direct communication with the landfill sediments, resulting in movement of landfill chemicals into the bay with tidal flow. This study, along with the study proposed below, is also critical for understanding movement of chemicals with water flow from the landfill into the wetlands.

BERC understands that PRC has installed monitoring wells between the wetland areas and the landfill, and that pumping tests have been conducted in other wells to assess hydraulic properties of the fill that has been placed in the area. However, such response tests may not be sensitive to locally very transmissive zones where gaps in the seawall or aquitard exist; BERC also understands that pump tests are not planned for the seawall and the raised area between the wetlands and bay along the western and southern sections of the seawall. BERC proposes an empirical approach to evaluate the potential connection between the bay and wetlands during a high tide period by installing several gauges in ponded waters, and observing water levels in piezometers and existing monitoring wells in the wetlands area. This study will then provide a practical assessment of the current integrity of the seawall and underlying Bay Mud (as an aquitard) system as a barrier for chemical migration out of the wetlands.

3.8 INTRINSIC TRANSFORMATION PROCESSES

The biological transformation of PAHs and PCBs in lagoon sediments and wetlands sediments will be evaluated in this task. The proposed studies recognize that some weathering of PAHs and PCBs

likely has occurred, but that the PAHs and PCBs previously found in site investigations may still be of ecological concern, requiring an evaluation of persistence of the remaining chemicals. Additionally, this task will also assess the potential/rate for methane generation in lagoon sediments, which is required information for design of the sediment capping alternative.

Initial efforts in this task will be an evaluation of the scientific literature to determine the expected range of transformation rates for these chemicals under the conditions found in the sediment strata and wetlands sediments. This information will be critically reviewed, summarized, and presented to the Navy for planning purposes.

Complementary to the information from the literature review, sediment samples from the lagoon and wetlands will be analyzed for transformation products and depth patterns that can be used to estimate transformation rates. One approach will be to compare the carbon isotope ratios for methane and for carbon dioxide collected from sediment with the same isotope ratios for the bulk organic material in the sediments. A decreased contribution from ^{14}C in these metabolic products would be evidence that the methane is derived from petroleum (fossil) materials and that intrinsic remediation of the petroleum constituents is occurring.

The PCB and PAH constituent fingerprint patterns in sediment samples will also be measured to assess any losses in the more reactive constituents of these mixtures. For example, the less chlorinated PCBs are known to be preferentially reactive in oxidizing environments, and the more highly chlorinated PCBs are reduced (or dechlorinated) in anaerobic systems. The PAHs with fewer rings are expected to be more readily oxidized than the higher ring PAHs. These data, along with the lead 210-based estimates of the deposition period of the corresponding sample depth, can then be used to estimate the rates at which PCBs and PAHs are being transformed in the sediment strata.

Laboratory studies also will be conducted under simulated in situ conditions to measure the methane generation from lagoon sediment cores. The presence of methane indicates methanogenesis is occurring by metabolism of anthropogenic or natural organics associated with Bay Mud and sediments; the potential generation of methane is of interest particularly for remedial alternatives such as capping of sediments in the Seaplane Lagoon.

If literature information and the physical characterization of the site locations indicate that PAHs and PCBs are expected to be transformed in site soils or sediments, the disappearance of PAHs and PCBs from anaerobic sediment core material will be monitored over a 6-month period. In a complementary effort, studies will be initiated using ^{14}C isotope labeled PAHs in continually mixed systems to assess the influence of environmental variables, such as oxygen and other natural oxidation promoters (nitrate, sulfate), and on the transformation rates of selected PAHs. The incorporation of the ^{14}C label into products and sediment organic matter will also be evaluated as discrete loss processes for the PAHs.

If the literature review and PCB congener analysis data show that PCBs are undergoing transformation, PCBs will be added to the sediments in the above laboratory experiment and the resulting loss of congeners will be measured over a 6-month period. These studies will also include field experiments to evaluate the potential for vegetation to promote the transformation reactions in site soils. As discussed in the introductory text for this section, the approach proposed for these transformation studies is planned to provide empirical data on the loss rates of these chemicals of concern that are immediately useful in future site planning or remediation at NAS Alameda.

3.9 PROCESSES IN DISTURBED SEDIMENT SYSTEMS

The dredging of the lagoon also is a potential remedial alternative for lagoon sediments, and a likely future construction activity for use of the lagoon as a recreational facility. Such removal actions will expose the sediments to oxidative processes not present in sediments below the top few centimeters of surface materials. Oxidized sediments are therefore expected to show a significantly different speciation of metals and toxicity.

One study will evaluate the leaching of metal constituents from sediment core samples using aerated water samples. Toxicity studies will also be conducted on artificially aerated sediments to evaluate the resulting toxicity in a disturbed sediment system and compared with the toxicity of the undisturbed sediment.

TABLES
&
FIGURES

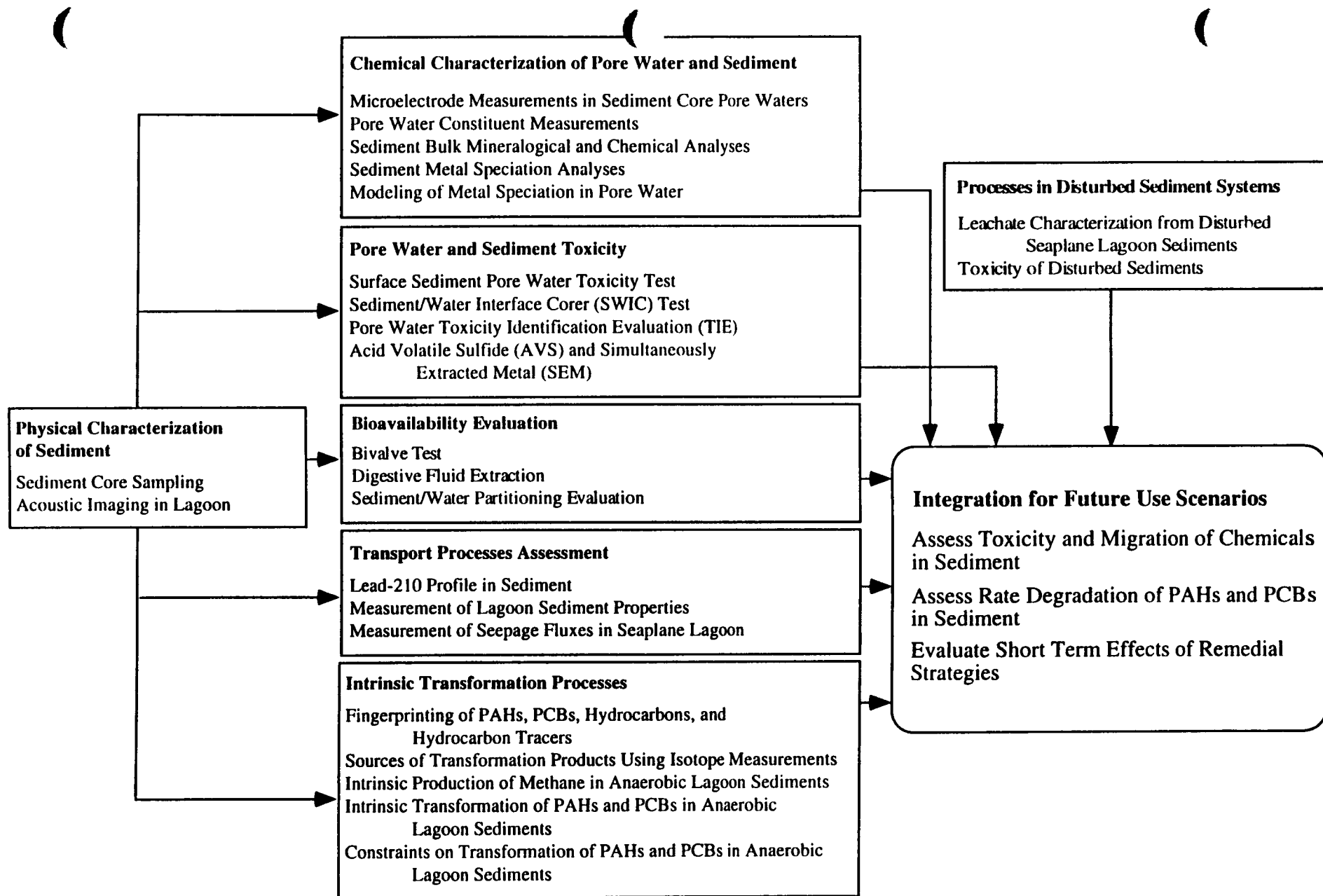


Figure 3-1. Tasks for Assessing Intrinsic Processes in Seaplane Lagoon

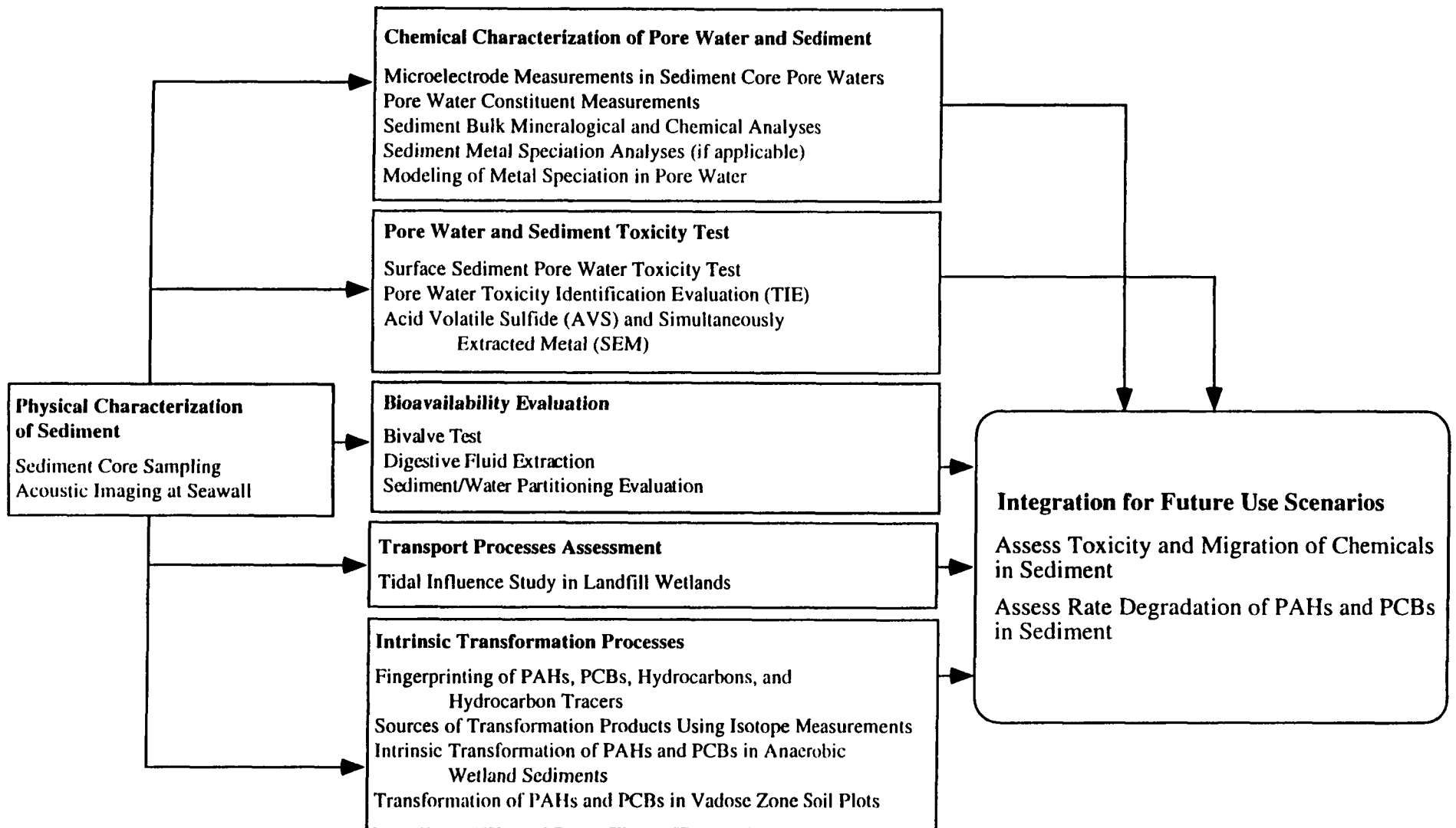


Figure 3-2. Tasks for Assessing Intrinsic Processes in West Beach Landfill Wetland

4.0 SAMPLING APPROACH

As discussed in Section 2, the Seaplane Lagoon and West Beach Landfill Wetlands have different topographies and histories of chemical releases; therefore, separate sampling strategies are required to obtain representative samples. The sampling strategies discussed below are designed to meet one or both of the following criteria: (1) collect samples from locations where the highest concentrations of chemicals of interest are present for chemical characterization, toxicity testing, and transformation studies, and (2) collect samples from locations that represent different environmental settings where transformation processes and migration pathways will be different and represent the range of conditions at the sites.

BERC studies will be conducted on samples collected from areas of the lagoon and wetlands that previous studies have shown the highest chemical concentrations, and thus are the more problematic for demonstrating intrinsic processes. Some of the studies will use innovative approaches that will use the expertise and unique facilities of the BERC investigators. Given that innovative methods have more uncertainties than data from more routine methods, it is important that some complementary information also be collected for some samples and methods to better define the sample character, behavior, and consistency among methods. This information then assists in defining the quality of the measurement in terms of the accuracy of the data and what the measurement represents.

The limited sampling locations are not intended to provide data on the nature and extent of chemicals present in the lagoon or wetlands. However, some information collected in the BERC studies is expected to be useful for extrapolation of the data to other locations at sites. Extrapolations of data will be accomplished by collaboration of the BERC investigators and the users of the study results at PRC and the Navy, and within the context of the uncertainties in the extrapolation of the data. Establishing accurate depth profiles of chemical distribution, chemical speciation, sediment toxicity, and deposition history requires that sediment cores be collected with minimum disturbance. For example, surface grab samples will be appropriate in evaluating surface sediment toxicity and bioavailability of chemicals. For deeper core samples where some surface disturbance is acceptable and larger volumes of sediment are required, a 4-inch gravity core sampler may be used. For other studies, such as chemical speciation of surface sediment pore waters, a more controllable and less disturbing "push" coring device will be used.

As part of the initial field sampling effort at each site, a few sediment corings will be collected and examined in the field prior to collection of the sediment cores that will be used in the individual laboratory studies. The Principal Investigator and Contract Quality Control Program Manager (CQCPM) will lead this initial field meeting and, with the Co-Principal Investigators, confirm that the cores are representative of expected site conditions and suitable for the proposed studies. For example, if the sediment column appears homogeneous, then segments from the core should be representative of the entire core for all studies. However, if the core shows a variegated appearance, then core segments may be chosen to provide "worse" case results in the planned tests and measurements. The Navy Remedial Project Manager (RPM) will also be requested to attend this initial field meeting so that any newly recognized uncertainties can be discussed and appropriate changes in the Work Plan can be agreed on before the laboratory studies begin.

4.1 SEAPLANE LAGOON

The lagoon locations to be sampled are all submerged at low tide; therefore, a barge or boat will be required for sampling. The major discharges to the Seaplane Lagoon are known to have occurred from the storm drains in the 1970s, and the sediments from this time period have subsequently been covered by more recent sediment deposition. The limited available data indicate that the sediments near the storm drain outfalls contain the higher concentrations of metals, PCBs and

PAHs. These data indicate that the chemical concentrations decrease with distance from the outfall. For the BERC studies, the areas near each of two sets of outfalls G/H and F/R will be considered to have the highest chemical concentrations in sediment. These two sets of outfalls correspond to sampling locations S3 and S4, respectively, in PRC's 1993 investigations; the depths from water surface to sediment surface were reported to be approximately 2.4 m and 4.3 m, respectively, at these locations. Toxicity and bioaccumulation studies will also collect samples from the center of the lagoon where less contaminated sediment is expected to be present. Some studies will also collect samples from the center of the lagoon where less contaminated sediment is expected to be present. Sampling tasks and the sediment collection program for the Seaplane Lagoon are summarized in the SAP.

The sediment core samples from the lagoon will be collected by a subcontractor with extensive experience sampling in San Francisco Bay. The intact core in a polymer sleeve (polycarbonate or acrylic) from the corer will be capped and transported to the dock immediately after collection. At the dock, the intact core will be transferred to the respective study group for cooling, preservation, and transport back to their laboratory. The depth of sediments in the lagoon are not known. For planning purposes, it has been assumed that the sediment depths are at least 3 m. The actual sediment depth will be determined by acoustic imaging, and any changes in the sampling depth will be evaluated and decided during the initial field meeting.

The procedure for collecting intact sediment cores will be tested during the initial sampling effort. The sediment core will be examined by the Principal Investigator and Co-Principal Investigators to examine lithology and reevaluate sampling and core segmenting strategy. In particular, the consistency of the sediment profile is not known, and may range from what has been described as a "black mayonnaise" material to a soil material that may have been used as fill in other parts of NAS Alameda. With concurrence of CQCPM and Navy RPM, the Principal Investigator may revise the sampling strategy or modify the sampling procedure to meet data quality objectives. If the sediment depth is sufficiently shallow such that the coring device can be pushed or driven into Bay Mud, a plug of mud in the bottom of the coring tube may allow the core to be readily retrieved. Sampling and testing of the Bay Mud strata is not planned. These procedures and other issues will be discussed and resolved during the initial field sampling effort, with a field variance documenting the changes in the sampling procedures.

4.2 WEST BEACH LANDFILL WETLANDS

Because of the site topography and seasonal and tidal inundation cycles, the West Beach Landfill Wetlands has a large diversity of microenvironments that may be studied. The sampling strategy will address only two types of environments - perennially saturated ponds and an upland vadose zone location. Based on previous investigation of the nature and extent of chemicals present at the site, concentrations of organic chemicals in soils or sediments are typically lower than 1 ppm, and it is probable that chemicals present in the wetlands area have been deposited from overland waterborne-soil erosion and by local windblown soil deposition from the adjoining landfill. Some chemicals, particularly PAHs, may also have been present on fill placed in this area.

Sediment cores from the wetland areas will be collected by persons with suitable training and field experience who are supervised by the Co-Principal Investigators. Sediment core samples will be collected from areas that are perennially saturated and apparently represent the ponded water table at the ground surface. Soil samples from an upland area will be sampled to a depth of 0.5m for microbial transformation studies. Additionally, soil gas samples will be collected from wetlands locations believed to be downgradient from the landfill to provide evidence of migration of transformation products in water from the landfill. The actual locations to be sampled will be selected during the initial field sampling visit depending on site conditions and access, and will be agreed upon by Principal Investigator, Navy RPM, and CQCPM. The sampling tasks and the sediment/soil sampling program are summarized in the SAP.

5.0 METHODS AND ANALYSES

This section describes the methods to be used and the data that will be collected in the treatability studies. The methods recognize that sample preservation, handling, and preparation for analyses of constituents are critical elements of obtaining quality data; details for methods are presented in the Sampling and Analysis Plan (SAP) (Appendix-B). Information for each method and analysis is described in three sections:

- Method describes the procedure and the analyses that will be performed, how the data are to be used in the project, and how the data or results will be reported.
- The Scope of the Method provides a brief description of the background related to the scientific rationale for the selection of the procedures and analyses and the limitations of the data to be obtained such that the reader can better understand the use of the data.
- The Status of the Method provides a brief discussion of the history of the analysis related to the precedents and innovative nature of the method, along with pertinent literature references.

To facilitate integration of data and comparison of results, measurements using the various methods will be conducted on sediment core segments from similar depths whenever applicable. The segment will be cut from the cylindrical core in the individual laboratory under specifications dictated by the method to be performed (that is, maintaining anaerobic conditions and collecting various lengths of core depending on sediment volume required). Typically, segments will be collected at 1 m and 2 m depths. The depth of segments or frequency of segments sampled is stated below for each method, and summarized in the SAP. The measurements and tests to be conducted for the Seaplane Lagoon (Site 17) and for the West Beach Landfill Wetlands (Site 2) are summarized in Tables 5-1 and 5-2, respectively, and a more complete description of the methods to be used follows. In the context of data use objectives, Table 5-3 summarizes the task and SOP number, the measurements to be conducted, and the intended or potential use of the data in the decision-making process at NAS Alameda.

To increase data quality, parameters of interest will be measured on core segments from more frequent intervals whenever possible and as dictated by project budget and factors such as sample/core holding times, the expected variation in properties with depth, and the availability of core sample (see Tables 5-1 and 5-2). Although it is recognized that lateral variation of the sediment composition does occur in sediment, testing of core samples from a lateral array for data replication is not included in the current plan.

5.1 PHYSICAL CHARACTERIZATION OF SEDIMENT

Knowledge of the physical setting of the lagoon and the landfill wetlands is critical for planning investigations to define the nature and extent of chemicals in these environments and for assessing remediation alternatives and their effectiveness. This information is also important for assessing the representativeness of the sediment samples collected in the past and proposed investigations. The acoustic imaging task described below is an important element as part of the intrinsic remediation and site characterization studies to be conducted by BERC; the results of the task will also be valuable to PRC for interpreting the results of their planned sediment boring and analysis program in the Seaplane Lagoon.

5.1.1 Acoustic Imaging

Method. This task will use Very High Resolution (VHR) acoustic profiling to describe the stratigraphy of the sediment, Bay Mud, and Merritt Sand zones underlying the Seaplane Lagoon.

The same technique will be used to evaluate the stratigraphy and features underlying the seawall along the western and southern edges of the West Beach Landfill Wetlands.

The results of the acoustic imaging will map the depth of sediments in the lagoon, determine the continuity of the major water bearing zones at both sites, and begin hydrologic connections between the landfill and San Francisco Bay.

Scope of the Method. VHR is useful for determining the lateral continuity of sediment horizons and for detecting sediment anomalies including buried and near-surface channels, shoals, scours, and filled areas. The complex physical, biological, and chemical stratification of NAS Alameda sediments makes the spatial characterization of these properties challenging. The maximum recording depth of the VHR system to be used is about 300 feet and the majority of VHR records reach depths of 40 to 50 feet. This allows visualization of the Holocene section in San Francisco Bay, and enables recording of most or all of the Holocene section in most marine and estuarine settings.

Acoustic reflection imaging can provide excellent subbottom images in shallow-water environments. However, the sensitivity of acoustic reflection imaging techniques to the presence of gas in sediment is a crucial variable in the applications and outcome of this study. Gas pockets produce a bright reflection on acoustic images, and provides a means of detecting sites of methanogenesis in shallow-water estuarine environments. Where substrates have been disturbed by large-scale erosional, mixing, or dredging processes, the continuity of the methanogenic layer is disrupted. Methanogenic processes are also strongly associated with native peat substrates. The geometry of gas-reflective elements can thus be useful for interpretation of the substrate types and their chemistry, biota, and history. Conversely, gas-charged sediments inhibit the imaging of deeper substrates. Deeper substrate geometries, i.e. ancient erosional surfaces and riverine deposits, marine depositional and erosional features, and deep dredge and fill features, can be masked by the sediment gas. These deeper features may only be locally and discontinuously imaged if sediment gas is pervasive at NAS Alameda. Previous experience also indicates that dredging and marine erosional processes tend to remove gas-charged sediments and provide "windows" through which deeper strata are imaged.

The imaging techniques to be used in this task have been field proven in previous studies of the essentially continuous young sedimentary section of San Francisco Bay. This field program has demonstrated a capability for VHR seismic reflection profiling in the detection, characterization, and interpretation of structural and sedimentary features in marine, lake, and river environments.

Status of the Method. The method has been successfully used by the CoPrincipal Investigator and USGS at locations in the Bay. Most recently, the Co-Principal Investigator used the method in an area from Yerba Buena Island to the Bay Bridge Toll Plaza (Williams, 1995).

References.

Williams, P.L. 1995. Seismic Stratigraphy and Bedrock Depth, Eastern Span, San Francisco - Oakland Bay Bridge. Caltrans Bridge Project Report.

5.2 CHEMICAL CHARACTERIZATION OF PORE WATER AND SEDIMENT

The tasks to characterize the inorganic chemistry of the sediments utilize several innovative techniques which provide an understanding of the toxicity of current constituents. This characterization will provide a framework for evaluating changes in sediment chemistry composition and resulting toxicity should the sediments be disturbed by remediation or recreational activities. Standard analyses for organic and inorganic constituents will be performed by PRC in a separate program. These results will be compared to the results of the BERC tasks as appropriate. Measurements of properties used for evaluating chemical transport are conducted as part of the

Transport Processes task (see Sec. 5.5). Analyses for specific PAH and PCB constituents will be performed as part of the Intrinsic Transformation Processes task (see Sec. 5.6).

5.2.1 Microelectrode Measurements in Sediment Core Pore Waters

Method. This task will assess the redox environment and concentrations of selected electron acceptors as a function of depth in a sediment core. This information will provide an understanding of the changes in pore water chemistry as a function of depth within the top 10 to 20 cm of sediment cores. Several sediment cores from one location in the Seaplane Lagoon and from a ponded area of the West Beach Landfill Wetlands will be analyzed using this method. This information is critical for understanding the toxicity and chemical and biological transformation of chemicals in these surface sediments. In order to determine the redox environment and concentrations of specific electron acceptors within this top 10 to 20 cm core of the sediment, a gold amalgam voltammetric microelectrode will be moved through the sediment column at progressively increasing depths to determine the dissolved Fe(II), Mn(II), O_2 , and total S(II) concentrations in pore waters. Similarly, pore water pH measurements will be made with a pH microelectrode (Brendel and Luther, 1995).

Scope of the Method. The redox microelectrode is limited to the analysis of dissolved Fe(II), Mn(II), O_2 , and total S(II) in the pore waters in an undisturbed intact sediment column (Brendel and Luther, 1995). The microelectrode has the powerful advantage of making electrochemical measurements as a function of depth at the millimeter scale. This scale is critical because the redox chemistry is expected to change dramatically within the first few centimeters below the sediment/water interface. While pore water samples will be extracted and analyzed over a deeper sediment core (see 5.2.2), an artifact of the pore water sampler is that pore water samples are averaged over discrete intervals (approximately 2-5 cm) and will not provide the depth resolution needed for the very shallow sediments. The accuracy of these analyses is contingent upon preserving the in situ redox environment of sediments during sampling and analysis (see SAP).

Status of the Method. The use of the redox microelectrode is a new technology and will require measurements on several cores to establish operating conditions. Although the use of the microelectrode will define pore water chemistry on a finer scale than traditional measures, the data from these experiments will be usefully compared to the pore water analyses described in 5.2.2 to assess the general accuracy of the microelectrode measurements (Brendel and Luther, 1995).

References.

Brendel P. J. and Luther, G. W. III (1995) Development of a Gold Amalgam Voltammetric Microelectrode for the Determination of Dissolved Fe, Mn, O_2 , and S(-II) in Pore Waters of Marine and Freshwater Sediments. *Environmental Science and Technology*, 29, 751-761.

5.2.2 Pore Water Constituent Measurements

Method. Standard chemical analysis methods will be used to measure the concentrations of major anions and major and trace metals in pore water from core segments over a 50 cm total depth. A pressurized pore water sampler will be used to sample pore waters from sediment intervals of approximately 2 to 5 cm, where water samples are squeezed from discrete segment layers of the sample core (Jahnke, 1988). The chemical analyses to be performed on the pore water samples are as follows: major anions (Cl^- , F^- , NO_3^- , NO_2^- , SO_4^{2-} and PO_4^{3-}), total dissolved major elements (Al, Ca, Fe, Na, Mg, Mn, and S), and total dissolved trace elements (Cd, Cu, Cr, Hg, Ni, Pb, Zn). All units will be expressed in $\mu g/L$.

Scope of the Method. The pore waters from depth intervals over 50 cm will be analyzed for the constituents listed above because concentrations of the metal contaminants in the sediments are reported to be significantly higher at depth. Because of the design of the squeezer, pore water

samples are averaged over discrete sediment intervals (approximately 2 to 5 cm). This technique cannot provide the depth resolution available using the microelectrode to analyze shallower sediment intervals. However, the squeezer sampler provides a sufficient volume of water to analyze a more complete list of chemical constituents than is available from the microelectrode. The analysis will be conducted using ion chromatography, inductively coupled plasma (ICP), mass spectrometry (MS) and ICP-atomic emission spectrometry (AES). The accuracy and representativeness of these analyses are contingent upon preserving the in-situ redox environment of sediments during sampling and analysis (see SAP).

Status of the Method. The pore water sampler will be similar to that designed by the Jahnke research group. Use of the pore water sampler has precedent in scientific literature. Analyses will be performed using standard methods described in the SAP.

Reference.

Jahnke, R. A. (1988) A Simple, Reliable, and Inexpensive Pore Water Sampler. *Limol. Oceanogr.* 33, 483-487.

5.2.3 Sediment Bulk Mineralogical and Chemical Analyses

Method. The bulk mineral and bulk chemical composition of the sediment will be determined at 20 cm intervals in a 2 m Seaplane Lagoon sediment core and in a 1 m core from the Landfill Westlands to ascertain any major changes in the sediments as a function of depth. These data will provide the link between the pore water chemistry and the sediment metal speciation, because they will profile metals concentrations and bulk mineralogy as function of depth. These data will be used to select samples of lagoon cores that are most representative of sediment composition for sediment speciation analyses (see Section 5.2.4). Additionally, the data will provide an archive of defined samples, if additional analyses are needed. Total sediment composition will be presented in concentration units. A list of the mineral phases identified in the sediments will be presented for each sample segment.

Scope of the Method. Bulk mineral composition will be determined by x-ray diffractometry (XRD). This technique identifies crystalline phases that comprise at least 2 percent by weight of the sediment. It is important to identify the mineral phases present because metals are known to be preferentially removed from water by sorbing or forming precipitates to specific minerals in the sediments. This information provides the baseline for initial analysis of the x-ray absorption spectroscopy (XAS) data (5.2.4). For example, if the sediment contains sulfides (pyrite) and expandable clays, the studies will be focused on evidence in the complex spectra for metal-sulfur, metal-oxygen, metal-iron, metal-silica, and metal-aluminum bonding and structures.

The bulk chemical composition will be determined by inductively-coupled plasma and atomic emission spectrometry (ICP-AES). In addition to determining the concentration of metal contaminants present, total bulk chemistry also provides information on the presence of amorphous phases which have a strong capacity to remove metals from the solution and can not be detected by XRD.

Status of the Method. Total sediment composition and bulk mineralogy determinations are routine techniques (see SAP).

5.2.4 Sediment Metal Speciation Analysis

Method. The redox status and speciation of Cd, Cu, Cr, Ni, Pb, and Zn in the sediment solid phase will be determined using synchrotron-based x-ray absorption spectroscopy (XAS). The metal speciation in the sediments is determined by its oxidation state and its coordination and bonding to other chemical constituents in the sediment (sulfide, carbonates, metal oxides, organic ligands, etc.). This information is required to determine the chemical reactions that control metal

distribution between the sediments and pore waters. It is also possible that the metals may exist as zero-valent metals from past disposal from the electroplating waste or as paint chips from past operations.

Based on the bulk sediment analyses, samples representative of anoxic and oxic environments will be analyzed by XAS for the Seaplane Lagoon. XAS analysis will also be conducted on West Beach Landfill Wetlands sediments and sediments used in the leaching experiments (see Section 5.7) if the concentration of metals are above the detection limit. Sample selection will be based on contaminant metals concentrations, bulk sediment concentrations, and bulk mineralogy to analyze samples that are both representative of the sediments and amenable to XAS analysis. For these samples, the results will identify the atomic structure of the contaminant including metal oxidation state and the phase in which the metal is chemically bonded.

Scope of the Method. Although this technique can be applied to sediments in contact with pore waters, for this project studies will be conducted on dry sediments because these analyses will be conducted at the Stanford Synchrotron Radiation Laboratory over time periods which may not correspond to sampling and obtaining recent core samples. Inasmuch as more than 99 percent of the total metals are estimated to be associated with sediments and not the aqueous phase, artifacts of analyzing dry sediments should be minimal (see SAP for description of sediment preservation).

As examples of speciation, metals sorbed to iron or manganese hydroxides or clay minerals in the upper oxic sediments may be dissolved from these mineral surfaces and released to the overlying water column. In the deeper anoxic sediment, the metals may be less available as insoluble metal sulfides. In this scenario, the metals must remain in an anoxic environment to be immobilized. It implies that in an oxic environment, the sulfide solids will dissolve and that some fraction of the metals will be sorbed to other mineral surfaces and some fraction will be leached into the overlying waters.

Operational detection limits for this technique vary between 50 ppm for Cd to 500 ppm for Pb, reflecting spectral properties inherent to specific metals. The presence of large concentrations of iron (> 20 wt. %) in the sediments also lowers signal statistics, hence lowering detection limits. For the deeper sediments containing higher levels of metals (reportedly 1,000 to 3,000 ppm), the detection limits should not hinder the application of XAS. However, in the oxic sediments, the metals concentrations of interest are near the detection limits of this technique. At the very minimum, the analyses will be able to determine the oxidation state in the oxic sediments, i.e. Cr(III) vs. Cr(VI).

Signal statistics will be optimized by increasing the number of scans, collecting data at cryogenic temperatures, diluting matrix interferences, and by using the best available detector technology. Details of the expected range of values, reporting/detection limits, and possible interferences of the specific analytical techniques are discussed in the SAP.

Status of the Method. XAS is one of the few techniques that can provide quantitative information about the local molecular structure of environmentally important elements at mineral/solution interfaces (Brown et. al., 1988; Brown 1990; Manceau and Charlet, 1992; O'Day et al., 1994a,b, 1995; Waychunas et. al., 1993). The XAS technique is still regarded as a research method, and for this task the technique requires access to the special capabilities at the Stanford Synchrotron Radiation Laboratory. The Co-Principal Investigator and co-workers (Carroll et. al., 1991, 1994, 1995) have demonstrated the feasibility of using this technique on metal ions in complicated acid mine drainage sediments (see SAP).

References.

Brown, G.E., Jr., Calas, G., Waychunas, G.A., and Petiau, J. (1988) X-ray Absorption Spectroscopy and its Applications in Mineralogy and Geochemistry. In: Spectroscopic

- Methods in Mineralogy and Geology, F. Hawthorne, ed., Reviews in Mineralogy 18, Washington, DC: Mineral. Soc. Of Amer., pp. 431-512.
- Brown, G.E., Jr. (1990) Spectroscopic Studies of Chemisorption Reaction Mechanisms at Oxide-water Interfaces. In: Mineral-Water Interface Geochemistry, M.F. Hochella, Jr. and A.F. White, eds., Reviews in Mineralogy 23, Washington, DC: Mineral. Soc. Amer., 309-363.
- Carroll, S.A. and Bruno, J., (1991). Mineral-solution Interaction in the U(VI)-CO₂-H₂O System. *Radiochimica Acta* 52/53, 187-193.
- Carroll, S., Phillips, B., O'Day, P., Waychunas, G., and Piechowski, M. (1994) Environmental Applications of EXAFS: Zinc Structure in Acid Mine Drainage Sediments. GSA Abstracts with Programs A-289.
- Carroll S., O'Day, P., Waychunas, G., and Phillips, B., (1995) EXAFS of Heavy Metal Coordination in Acid Mine Drainage. **American Chemical Society GEOC 008.**
- Manceau, A. and Charlet, L. (1992) X-ray Absorption Spectroscopic Study of the Sorption of Cr(II) at the Oxide-water Interface. I. Molecular Mechanism of Cr(III) Oxidation on Mn Oxides. *J. Colloid Interface Sci.* 148, 425-442.
- O'Day, P.A., Brown, G.E., Jr., and Parks, G.A. (1994a) X-ray Absorption Spectroscopy of Cobalt(II) Multinuclear Surface Complexes and Surface Precipitates on Kaolinite. *J. Colloid Interface Sci.* 165, 269-289.
- O'Day, P.A., Brown, G.E., Jr., and Parks, G.A. (1994b) Molecular Structure and Binding Sites of Cobalt(II) Surface Complexes on Kaolinite from X-ray Absorption Spectroscopy. *Clays Clay Miner.* 42, 337-355.
- O'Day, P.A., Carroll, S.A., Waychunas, G.A., and Phillips, B., (1995) XAS of Trace Element Coordination in Natural Sediments at Ambient and Cryogenic Temperatures. *Physica B.* 208-209, p.309-310.
- Waychunas, G.A., Rea, B.A., Fuller, C.C., and Davis, J.A. (1993) Surface Chemistry of Ferrihydrite: Part 1. EXAFS Studies of the Geometry of Coprecipitated and Adsorbed Arsenate. *Geochim. Cosmochim. Acta* 57, 2251-2282.

5.2.5 Modeling of Metal Speciation in Pore Water

Method. Pore water chemistry will be simulated using the measured solution composition data, the models REACT (Bethke, 1994) and EQ3/EQ6 (Wolery, 1992), geochemical codes and the SUPCRT92 thermodynamic database (Johnson et. al., 1992). This modeling effort will evaluate the solid phases that thermodynamically control the distribution of metals between the solids and more mobile pore waters. These codes also allow for redox disequilibria and reaction path analyses. Therefore, these models can also be used as a geochemical tool to estimate conditions resulting from proposed remediation strategies. The results of modeling will be reported in terms of the metal speciation and overall chemical saturation state as a function of redox potential and solution pH.

Scope of the Method. These calculations are limited by the available thermodynamic and kinetic data from literature. These data will be critically evaluated for their use in the project. These uncertainties in the data will be considered in the interpretation of the results using sensitivity analyses.

Status of the Method. REACT (Bethke 1994) and EQ3/EQ6 (Wolery 1992) are geochemical codes in common use in the geochemical community. These codes include geochemical equilibria, redox disequilibria, sorption of metals at iron hydroxides, and simple reaction kinetics. The Co-Principal Investigator for this effort at LLNL has experience with these models, and resources at LLNL provide the capacity to augment the data set with newly determined thermodynamic and kinetic values.

References.

- Bethke C. M. (1994) *The Geochemist's Workbench. A Users Guide to Rxn, Act2, Tact, React, and Gtplot*. Board of Trustees of the University of Illinois.
- Johnson, J. W., Oelkers, E. H., and Helgeson, H. C. (1992) SUPCRT92: A Software Package for Calculating the Standard Molal Thermodynamic Properties of Minerals, Gases, Aqueous Species and Reactions from 1 to 5000 Bar and 0 to 1000C. *Computers and Geosciences* 8, 899-947.
- Wolery, T. J. (1992) EQ3NR, A Computer Program for Geochemical Aqueous Speciation-solubility Calculations: Theoretical manual, user's guide, and related documentation. Lawrence Livermore National Laboratory, UCRL-MA-110662 PTIII.

5.3 PORE WATER AND SEDIMENT TOXICITY TESTS

This section discusses the series of toxicity tests and toxicity identification evaluations (TIE) tests that will be conducted on sediments from the Seaplane Lagoon and the West Beach Landfill Wetlands. The tests will be conducted to evaluate developmental abnormalities using echinoderm embryos and survival using amphipods. The tests will be performed using pore waters from surface sediments in the lagoon and from the Landfill Wetlands. The chemicals responsible for toxicity in pore water will be determined by Toxicity Identification Evaluation (TIE) procedures. Additionally, the toxicity at the interface of water and sediment will be tested for both surface sediments and for deeper core sediment in the Seaplane Lagoon. Toxicity to the same organisms in a disturbed sediment system from the Seaplane Lagoon will also be tested, and is described in Section 5.7.

5.3.1 Surface Sediment Pore Water Toxicity Tests

5.3.1.1 Developmental (Embryo) Toxicity Tests

Method. The 72-hour developmental toxicity tests using echinoderm embryos are designed to determine adverse developmental effects of chemicals present in surface pore waters. Pore waters extracted from surface sediments at three Lagoon locations and from four Landfill Wetlands locations will be used in the tests. Controls using water and references using aliquots of site water will be used to compare the pore water toxicity results. If echinoderm embryos are not available, bivalve embryos will be used.

The results of these tests will evaluate toxicity associated with surface sediment pore water, and will be compared to the toxicity resulting from direct exposure to surficial sediment (see 5.3.2). For pore water samples where toxicity is observed, a series of chemical separations (TIE) will be performed on the pore water, with reexposure to the pore water aliquots conducted to identify the source of toxicity. The pore water toxicity of subsurface sediments will not be tested because these water samples are subject to significant oxidation during the test and any toxicity results are not relevant to environmental conditions.

Scope of the Method. Pore water is often considered the prime exposure route to organisms in sediment. Exposure of organisms to chemicals in pore water can have effects including morphological, physiological, functional changes as well as limited/no changes and mortality. The observed pore water effects on embryo development is limited to the test species, which were selected on basis their sensitivities to sediment contaminants and their use in other studies in the Bay area. While this species-specific limitation may negate the extrapolation of the overall sediment toxicity findings, it is still the best indicator of toxicity in pore water.

The pore water samples to be used in the developmental tests will be extracted from sediment samples using centrifugation and passive filtration procedures. The percent normal embryo

development will be determined for each test. Water quality parameters such as salinity, pH, percent oxygen and ammonia will be measured at the beginning of each test (Apha, 1995). Temperature is recorded daily. The details of this test are contained in the SAP.

Developmental abnormalities are assessed in formalin fixed samples following a 72-hour exposure.

Status of Method. The embryo tests are based on modified ASTM method E-724-89 (ASTM, 1989) using methods discussed in Anderson et. al., (1995). The pore water extraction procedures are not regarded as standard practices but are based on developing consensus within the toxicological field that pore water should be extracted by centrifugation.

References.

- American Public Health Association (APHA). 1995. *Standards Methods for the Examination of Water and Wastewater*. 19th Edition., Washington, DC.
- American Society for Testing and Materials (ASTM), 1989. *Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of four species of Saltwater Bivalve Molluscs*. Method E 724-89. American Society for Testing and Materials, Philadelphia, PA.
- Anderson, S.L., J.P. Knezovich, J. Jelinski, and D.J. Steichen. 1995. The Utility of using Pore-Water Toxicity Tests to Develop Site-Specific Marine Sediment Quality Objectives for Metals. LBL-37615.

5.3.1.2 Survival (Amphipod) Test

Method. A 10-day survival test using the amphipod, Eohaustorius estuarius, will be used to assess survival in pore waters collected from the same sediment sources as used in the developmental toxicity tests (see 5.3.1.1). Samples used for this test will be collected from the same areas as the ones used in the embryo test and are discussed in the Sampling and Analysis Plan.

The amphipod survival test will provide supplemental information on the toxicity of the pore water which will, in turn, further characterize the extent of sediment toxicity in the Seaplane Lagoon and the West Beach Landfill Wetlands. The results of these tests will help to characterize toxicity associated with pore water from surface sediment pore water, and will be compared to the toxicity resulting from direct exposure to surfacial sediment (see 5.3.2). As with the developmental toxicity tests, when pore water toxicity is observed, a series of chemical separations (TIE) will be performed on the pore water, with reexposure to the pore water aliquots conducted to identify the source of toxicity. The pore water toxicity of subsurface sediments will not be tested because these samples are subject to significant oxidation during the test and any toxicity results are not relevant to environmental conditions.

Standard statistical procedures (USEPA, 1994) will be used to ascertain whether toxicity in presumed contaminated sites varies significantly from toxicity observed in laboratory controls and in pore water obtained from reference sediment.

Scope of Method. The amphipod 10 day survival test will be based on a modification of a method by Swartz *et al.* (1985). For each test, five amphipods will be exposed to the pore water solutions. Test parameters of interest will be the number of amphipods that survive. Amphipod survival will be monitored daily and the dead ones will be removed from the test chambers. Temperature will be monitored daily. Salinity, pH, percent oxygen and ammonia will be measured at the beginning and end of each test (Apha, 1995). The details of this test are contained in the SAP.

Status of Method. This method is based on solid phase sediment toxicity methods for amphipods. However, modifications have been made for pore water exposures. The principal modification is that amphipods are exposed in 50 ml pore water rather than in solid phase sediments.

References.

- American Public Health Association (APHA). 1995. *Standard Methods for the Examination of Water and Wastewater*. 19th Edition., Washington, DC.
- Swartz. R.C., W.A. De Ben, J.K.P. Jones, J.O. Lamberson, and F.A. Cole. 1985. Phoxocephalid Amphipod Bioassay for Marine Sediment Toxicity. *Aquatic Toxicology and Hazard Assessment: Seventh Symposium*, ASTM STP 854. R.D. Cardwell, R.Purdy, and R.C. Bahner, Eds, American Society for Testing and Materials, Philadelphia, PA, pp. 284-307.
- United States Environmental Protection Agency (USEPA). 1994. *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms*. EPA/600/R95/136. August, 1995.

5.3.2 Sediment/Water Interface Corer (SWIC) Test

Method. This test will evaluate survival and developmental toxicity at the sediment-water interface using the same two species (an amphipod and echinoderm embryos) as used for the pore water toxicity tests. The test apparatus consists of a mesh enclosure containing the test species that is then placed on an intact sediment core to simulate the actual exposure experienced by epibenthic organisms. This device is described in the Sampling and Analysis Plan. The surface sediment cores used in the tests will be collected from the same three locations in the Seaplane Lagoon as the pore water sample tests. In second phase of experiments, the SWIC test will be conducted using intact sediment cores from depths at 0-m, 1-m and 2-m collected at two locations near the outfalls where the highest chemical concentrations in sediments are expected.

The test results for surface sediment systems will be compared to the respective pore water tests to determine whether toxicity varies significantly among different exposure techniques. The results for the second phase of experiments that use the deeper core segments will be used to determine the potential toxicity should the overlying sediments be removed and benthic organisms then be exposed to the *nouveau* sediment bed that remains. The results of the SWIC tests will then be used to evaluate whether excavation of sediments will mitigate benthic toxicity in the Seaplane Lagoon. SWIC tests will not be performed using Landfill Wetland sediments because the site has not been sufficiently characterized to warrant advanced testing.

Scope of Method. The two species (amphipod and echinoderm) will be placed in separate whole sediment cores (approximately 12 cm length) using the sediment water interface exposure system shown in the SAP. Organisms will be observed only at the end of the exposure period to avoid disturbing the integrity of the core. These tests are described in greater detail in the Sampling and Analysis Plan. The reported results will consist of observed changes in the test species, including developmental anomalies in urchin embryo and mortality in amphipods. Reported data will be limited to effects on these two species as a function of depth. Correlations between toxicity and variations in chemical concentration with depth will also be examined.

Status of Method. The SWIC test represents an innovative procedure that has been used by the Co-Principal Investigators and one other research laboratory in California, and is an important test for better simulating epibenthic exposures than pore water exposures alone.

Method References.

- Anderson, B.S., J.W. Hunt, M. Hester, and B.M. Phillips. 1995. Assessment of Sediment Toxicity at the Sediment-Water Interface. In Press in *Techniques in Aquatic Toxicity*. CRC Press, Boca Raton, Florida.

5.3.3 Pore Water Toxicity Identification Evaluations (TIE)

The objectives of TIE are to identify the classes and then specific chemicals responsible for pore water toxicity at the Seaplane Lagoon and the West Beach Landfill Wetlands. The tests are conducted in phases to evaluate toxicity due to (1) ammonia and sulfide, (2) dissolved metals, and (3) organic chemical constituents. (See Figure 5-1 "Approach for toxicity identification evaluations.")

5.3.3.1 Ammonia and Sulfide Toxicity Assessment

Method. The test will measure total ammonia and sulfide concentrations using an ion-specific electrode, and a modification of the methylene-blue method, respectively. The details of these tests are contained in the Sampling and Analysis Plan. Ammonia and sulfide tests are necessary to establish whether these chemicals are present at concentrations that are toxic to test organisms used to evaluate sediment toxicity.

Scope of Method. Ammonia and sulfide occur naturally in anoxic environments, and can be a source of toxicity to benthic organisms. The concentrations of these constituents and their toxicity is pH dependent. Both NH_3 and H_2S values in excess of LC- or EC- 50s will be reported as toxic units - (TU) and will be removed from pore water via passage through zeolite and by gentle aeration for 2 hours before the subsequent testing phase.

Status of Method. Determination of ammonia and sulfide as H_2S is based on standard/modified methods. Data recently developed by the CoPrincipal Investigators will permit the evaluation of their potential contribution to sediment toxicity.

References.

American Public Health Association (APHA). 1995. *Standard Methods for the Examination of Water and Wastewater*. 19th Edition., Washington, DC.

5.3.3.2 Metals Toxicity Assessment

Method. This test will evaluate sediment toxicity due to the presence of bioavailable metals. (See Figure 5-2 "Pathway for the assessment of metalinduced toxicity.") This procedure will add a metal chelator to an aliquot of pore water showing toxicity to determine if selected metals may be responsible for the observed toxicity. Specifically, the chelator ethylenediaminetetracetic acid (EDTA) will be added to water to reduce the bioavailability of Cd, Cu, Cr, Hg, Ni, Pb and Zn. Following chelation, the pore water will be evaluated for toxicity to determine whether heavy metals were responsible for toxicity. The details of this test are contained in the Sampling and Analysis Plan.

If a decrease in toxicity due to the addition of chelators to pore water is observed, the untreated pore water solutions will be analyzed for specific trace metals to determine the concentrations of metals present. For those metals believed to be the cause of toxicity, seawater solutions will be prepared and dosed with metal concentrations to simulate and confirm the toxicity of metals in the system.

Scope of Method. The metal chelation procedure will be conducted in parallel with toxicity evaluations. Chelators such as EDTA are well known to decrease the availability of metals to exhibit toxicity. Analyses of individual metals in pore water by standard spectrophotometry will permit comparison to existing toxicity data for metals. Contribution of individual metals to toxicity can then be determined. The details of this test are contained in the Sampling and Analysis Plan.

Status of Method. The use of chelating agents to control metal availability in aqueous solutions is a well established procedure, and has been used by the Co-Principal Investigator in TIE analyses.

References.

- Allen, H.E., G.Fu, and B. Deng. 1993. Analysis of Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metals for the Estimation of Potential Toxicity in Aquatic Sediments. *Environ. Toxicol. Chem.* 12: 1441-1453.
- Ankley, G.T., V.R. Mattson, E.N. Leonard, C.W. West, and J.L. Bennett. 1993. Predicting the Acute Toxicity of Copper in Freshwater Sediments: Evaluation of the Role of Acid-volatile Sulfide. *Environ. Toxicol. Chem.* 12:315-320.

5.3.3.3 Polar and Non Polar Organic Toxicity Assessment

Method. This test assesses the toxicity that can be attributed to organic chemicals in pore waters. Organic chemicals in pore water will be fractionated using solid-phase extraction (SPE) technique followed by fractionation using high pressure liquid chromatography (HPLC). The resulting HPLC fractions are then subjected to gas chromatography/mass spectrophotometry (GC/MS) or HPLC/MS analyses for the determination of polar and non-polar chemicals, respectively. The details of this test are contained in the Sampling and Analysis Plan.

Method Scope. The different organic toxicants characterized by class and by concentrations will provide additional data for use in these toxicity tests. Standard concentration units will be used to report analytical and toxicity data. Figure 5-3 shows the pathway for the determination of organic compound induced toxicity. The SPE techniques isolate the toxicants and prevent interference during analyses by HPLC, HPLC/MS and GC/MS methods.

Pore water demonstrating toxicity will be fractionated into acid-, base- and neutral classes which would then be analyzed by standard chromatographic methods. The separation process employs the behavior that acidic non-polar compounds like phenols, basic non-polar compounds like aromatic amines and neutral chemicals like PCBs, pesticides and PAHs, will pass through C-18 columns at pH values of 6, 9, and 7.8, respectively.

Status of Method. The methods for analysis of organic constituents in the aqueous phase generally follows procedures described in SW 846. The CoPrincipal Investigator has extensive experience in using the separation methods and organic analysis procedures in TIE efforts.

References.

- Ankley, G.T., M.K. Schubauer-Berigan, J.R. Dierkes, and M.T. Lukasewycz. 1991. Sediment Toxicity Identification; Phase I (characterization), Phase II (identification) and Phase III (confirmation) Modifications of Effluent Procedures. Technical report 08-91. (EPA/600/69 1/007).
- Burkhard, L.P., and E.J. Durhan. 1991. Identification of Nonpolar Toxicants in Effluents using Toxicity-based Fractionation with Gas Chromatography/mass Spectrometry. *Anal. l. Chem.* 63: 277-283.

5.3.4 Acid Volatile Sulfide and Simultaneously Extracted Metal

Method. The test for acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) determines the sulfide and metal concentrations in solutions of sediment samples extracted with concentrated hydrochloric acid. Comparisons of the sulfide and metal concentrations are then used to predict the toxicity of sediment associated with bioavailable metals. SEM/ AVS measurements will be conducted on all surface and subsurface samples collected for toxicity testing.

A SEM to AVS ratio of less than unity indicates that all metal is bound as sulfide and no toxicity is predicted; a ratio greater than unity indicates that metal is bioavailable and may exhibit toxicity. The test results are also applicable to assess the amount of metals that would be released by oxidation processes if the sediments are aerated, such as when disturbed during excavation.

Scope of the Method. The SEM/AVS test assumes that sulfide precipitation controls the solubility of metals in solution in anoxic sediment systems. As discussed earlier, metals in sediments can be present as the insoluble metals sulfides. This method is applicable to the anoxic sediments at the two sites and will depend on sequential analysis for sulfides and heavy metals. Thus, the AVS measures the total sulfide concentration (solid and aqueous phase), and the SEM measures the readily extractable metals concentration in the sediment. Heavy metals to be quantified include Cd, Cu, Cr, Zn, Pb, Ni and Hg. Literature reports that sediments with high metal concentrations and high AVS do not exhibit metal related toxicity.

Status of Method. The SEM/AVS method has been published in peer-reviewed literature, and has been extensively tested to demonstrate its validity of predicting sediment toxicity in anoxic systems.

References.

- Allen, H.E., G. Fu, and B. Deng. 1993. Analysis of Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metals for the Estimation of Potential Toxicity in Aquatic Sediments. *Environ. Toxicol. Chem.* 12:1441-1453.
- American Public Health Association (APHA). 1985. *Standard Methods for the Examination of Water and Wastewater*, 16th ed. Washington, DC.
- Ankley, G.T., V.R. Mattson, E.N. Leonard, C.W. West, and J.L. Bennett. 1993. Predicting the Acute Toxicity of Copper in Freshwater Sediments: Evaluation of the Role of Acid-volatile Sulfide. *Environ. Toxicol. Chem.* 12:315-320.
- DiToro, D.M., J.H. Mahony, D.J. Hansen, K.J. Scott, A.R. Carlson, and G.T. Ankley, 1992. Acid Volatile Sulfide Predicts the Acute Toxicity of Cadmium and Nickel in Sediments. *Environ. Sci. Techol.* 26:96-101.
- Zhuang, Y. H.E. Allen, and G. Fu, 1994. Effect of Aeration of Sediment on Cadmium Binding. *Environ. Toxicol. Chem.* 13:717-724.

5.4 BIOAVAILABILITY EVALUATION

The bioavailability evaluation is intended to assess the uptake of chemicals from contaminated sediments from the Seaplane Lagoon and from the West Beach Landfill Wetlands. The objectives of the bioavailability tests include determining (1) the degree to which chemicals in sediment bioavailable to deposit-feeding invertebrates, and from which sediment locations in the chemicals are most bioavailable, (2) which chemicals exhibit the greatest bioavailability; and (3) how bioaccumulation of contaminants from these sediments compare with other locations within San Francisco Bay. Bioavailability will be evaluated using two methods, (1) a standardized bivalve bioaccumulation test, and (2) a sediment extraction procedure using the digestive fluids of a marine worm. The two tests will be conducted on split samples from homogenized sediment samples from several locations to provide a direct comparison of the two bioavailability methods.

5.4.1 Bivalve Bioaccumulation

Method. Bivalve bioaccumulation tests have been one of the principal traditional means of assessing the bioavailability of sediment-associated contaminants. The bivalve bioaccumulation test will be conducted by exposing clams (*Macoma nasuta*) to sediment samples collected from the locations at the Seaplane Lagoon, the West Beach Landfill Wetlands, San Francisco Bay reference sites and a control sediment (home site). The bivalves will be exposed to the sediments for 28 days, and the tissue will then be analyzed for PAHs, PCBs, and DDT. The bivalves used in the tests will be obtained from a relatively pristine control site (e.g. Tomales Bay, California or

Sequim Bay/Discovery Bay in Washington State). The experimental procedures and details of this test are contained in the Sampling and Analysis Plan.

Scope of Method. The bivalve bioaccumulation test simulates the chemical exposure and uptake of a deposit-feeding bivalve to contaminated sediment. Sediments to be tested will be placed in aquaria and the bivalves added to the sediment. After 28 days, the bivalves will be sacrificed and the tissue residue analyzed by GC or GC/MS. Tissue residue data will be contrasted to data sets available elsewhere such as bivalve bioaccumulation data from the Port of Oakland, and the Food and Drug Administration's action levels for PCB and DDT. Data on bioaccumulation from Seaplane Lagoon and West Beach Landfill will be compared with data from the three San Francisco Bay reference sites (see 5.4.2).

For purposes of comparison, large bivalves will be collected during sampling in the Seaplane Lagoon, and the tissue will be analyzed then for the same suite of organic chemicals. These data will establish the degree to which 28 day laboratory bivalve exposure tests accurately reflect in situ bioaccumulation by resident species.

Status of Method. Bioaccumulation by the clam, *Macoma nasuta*, is a standardized and widely used procedure to test bioavailability of sediment-bound contaminants. Dredged material throughout the country is typically tested by this procedure to determine environmentally-sound disposal options (EPA/COE, 1994) and the EPA has promulgated standard procedures for conducting these tests (Lee et al., 1989).

References.

- Lee, H., B. L. Boese, J. Pelletier, M. Winsor, D. T. Specht, and R. C. Randall. 1989. Guidance Manual: Bedded Sediment Bioaccumulation Tests. Prepared by the U. S. Environmental Protection Agency. EPA/600/x89/30.
- EPA/COE. 1994. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (Draft) Prepared by the U. S. Environmental Protection Agency and the U. S. Army Corps of Engineers. EPA-823-B-94-002.

5.4.2 Digestive Fluid Extraction

Method. Bioavailability will also be assessed by a novel method of sediment extraction using the digestive fluid from a marine worm, *Arenicola brasiliensis*. Digestive solubilization will be reproduced in vitro using the digestive fluid extracted from sacrificed worms. Selected organic chemicals solubilized into the digestive fluid by this procedure will be measured as the bioavailable contaminant fraction. The sediment concentrations of PAHs, PCBs and DDT will be quantified ($\mu\text{g/kg}$), as well as the fraction of the contaminant solubilized by digestive fluid ($\mu\text{g/l}$). The solubilized contaminants will be regarded as potentially bioavailable, representing the maximum concentration of organic chemicals that can be extracted from sediment as that sediment passes through the gut of a deposit-feeding organism. The details of this test are contained in the Sampling and Analysis Plan.

Sediment cores will be collected from locations near outfalls in the Seaplane Lagoon. These cores will be used for bioavailability testing using sediment segments from surface sediments and from depths of 1 meter and 2 meters. Tests will also be conducted using surficial sediment samples collected from three locations in the permanently flooded areas of the West Beach Landfill Wetlands. Additionally, a total of three reference samples will also be obtained from three central Bay sites, roughly off Alameda, Yerba Buena and Tiburon. Ancillary data including TOC, water content and grain size will also be measured from the sediment samples.

Scope of Method. The deposit-feeding polychaete *Arenicola brasiliensis* will be collected from intertidal areas of the central California coast, and digestive fluid extracted. The sediment samples

will be incubated in the digestive fluid for 4 hours after which the suspension will be centrifuged and the supernatant recovered for organic analyses by GC or GC/MS.

The method is based on the assumptions that ingestion of contaminated food is an important route of contaminant uptake and that solubilization of contaminants during digestion is a necessary prerequisite for bioaccumulation. These assumptions are likely to be most valid for hydrophobic and persistent contaminants with a high bioaccumulation potential, and it is compounds such as these on which we will focus (i.e. PAH, PCB, DDT).

Status of Method. The method is based on a published procedure in the literature (Mayer et al., in press). It was originally developed with funding by the Office of Naval Research, and has subsequently been used to evaluate sediments in southern California, San Francisco Bay, New England and Europe.

References.

Mayer, L., Z. Chen, R. Findlay, J. Fang, S. Sampson, L. Self, P. Jumars, C. Quetel, and O. Donard. 1996 In press. Bioavailability of Sedimentary Contaminants Subject to Deposit-feeder Digestion. Environmental Science and Technology.

5.4.3 Sediment/Water Partitioning Evaluation

Method. The sediment water partitioning of PAHs and PCBs will be evaluated using organic carbon measurements (see 5.5.2) and the measured concentration of the PAHs and PCBs in sediments using a Freundlich isotherm relationship. These data are important for understanding the potential mobility and bioavailability of hydrophobic organic chemicals in sediments in the Seaplane Lagoon and Landfill Wetlands.

Scope of the Method. The estimation of sediment/water partitioning of organic chemicals is a well established procedure (Karickhoff, 1984; Schwarzenbach et al., 1993). The organic carbon data will be evaluated to ascertain whether the organic phase media is better regarded as soil organic matter, where a Freundlich isotherm sorption is appropriate, or as a hydrocarbon phase where a Raoult's Law relationship controls the partitioning. Because of the expected low concentrations of PAHs or PCBs in the Seaplane Lagoon and Landfill Wetlands and their large partitioning (equilibrium) constants, the calculations will be focused on estimating the upper limits on concentrations and associated uncertainties of these chemicals in pore waters and overlying waters.

Status of the Method. The use of organic carbon data and sorption isotherms is documented in the environmental literature (Karickhoff, 1984; Schwarzenbach et al., 1993).

References.

Karickhoff, S.W., 1984 Organic Pollution Sorption in Aquatic Systems. *J. Hydraulic Engineering* 110, 707-735.
Schwarzenbach, R.P., P.M. Gschwend, and P.M. Imboden, 1993. *Environmental Organic Chemistry* John Wiley and Sons, New York.

5.5 TRANSPORT PROCESSES ASSESSMENT

Information on the deposition history of chemicals in the Seaplane Lagoon and the current and future migration of chemicals with groundwater in the saturated zone is required for assessing the risks at the site. This information is also critical for selecting remedial options that include either an intrinsic remediation component or a "no further action" decision. These are proposed studies on transport processes for chemical migration from the West Beach Landfill and from the Landfill

Wetlands into the Bay waters. The studies described below represent an approach to provide this information.

5.5.1 Lead-210 Profile in Sediment

Method. This task will develop a profile of the concentration of the naturally occurring radioisotope lead-210 as a function of depth in a sediment core from the Seaplane Lagoon. This profile will be used to estimate the age of the sediment layers and sediment accumulation rates based on the known rate of lead-210 decay. Techniques using such radioisotopes are very useful in tagging sediments such that through the natural isotopic decay, the age of the sediments can be determined. The main focus will be on lead-210; other radioisotopes will be explored if present.

This technique will provide estimates of sediment age (years before present) as a function of sediment depth at 20 cm intervals using a 3 m sediment core from the Seaplane Lagoon. These data will be integrated with data from the transformation tasks to evaluate intrinsic transformation rates of organic chemicals of concern at the Seaplane Lagoon. Lead-210 profiles as a function of sediment depth will not be developed for the West Beach Landfill Wetlands because the long term sedimentary profile has not been accumulating in the ponded area of the wetlands. Actual lead-210 measurements are presented as activities (Becquerel/kg, or Bq/kg of sediment).

Scope of the Method. The major assumption of this commonly used technique is that lead-210 is elevated in near-surface sediments due to the deposition of lead-210 into sediments and soils from the decay of radon-222 in the atmosphere. This radioactive decay chain has its origin in the decay of uranium-238 that is naturally present in most soils. The isotopic decay series includes the following isotopes:

Uranium-238 → Uranium-234 → Thorium-230 → Radium-226
→ Radon-222 → Polonium-218 → Lead-214 → Bismuth-214
→ Polonium-214 → Lead-210 → Thallium-210 → Bismuth-210
→ Polonium-210 → Lead-206 (stable).

When atmospheric radon decays, lead-210 is rapidly formed and strongly partitions onto atmospheric particles, which are deposited and accumulate in the sediment. Lead-210 has a half life of 22.3 years and provides a good tool for evaluating sedimentary processes over the last 10 to 200 years (one half to 10 half-lives).

The application of the method to radiodating sediments initially assumes that excess lead-210 in the sedimentary profile comes from the atmospheric deposition of lead-210 that decayed from radon-222. In the San Francisco Bay area the radon in the atmosphere reflects the uranium content of native near-surface rocks and soils. Studies of Fuller and Hammond (1983) in the Newark Slough near South San Francisco Bay observed a mean lead-210 fallout rate of 0.15 ± 0.01 dpm/cm²-yr in rainwater and 0.14 dpm/cm²-yr from the sediment profile (1 dpm=1/60 Bq). These values are expected to be found in the Seaplane Lagoon sedimentary profile and are within the range of measurement techniques for a sedimentation rate of 1 gram per square centimeter per year (g/cm²-yr).

The assumption of excess lead-210 coming from atmospheric radon would be incorrect if radium-based luminescent paints have been released into the Seaplane Lagoon or nearby waters during past Navy operations. However, in this case the presence of radium-based luminescent paint waste in the sediment profile will provide a stronger radioisotope signal that provides an alternative dating tool for the time period of 1940 to 1950 when these paints were likely used. If sediment samples at a depth demonstrate an elevated level of lead-210, those samples will be subjected to gamma particle counting to confirm the presence of radium-226. Gamma counting will also measure the

activity of cesium-137, and this information can also be used for dating the sediment profile. Cesium-137 has a half life of 30 years and was introduced into the hydrologic cycle during atmospheric nuclear weapons testing and some nuclear reactor accidents. Because cesium strongly partitions onto particles, it is also a good dating tool for determining sediment ages and sediment accumulation rates; most investigations that age-date sedimentary profiles utilize lead-210 in conjunction with cesium-137. The analysis procedures for radium-226 and cesium-137 are described in the SAP.

Another initial assumption in interpreting sedimentary profiles is that the sediment is not mixed. This condition was likely at the Seaplane Lagoon given the contamination levels that ought to have limited macrofauna bioturbation. The actual profiles of redox sensitive chemical species such as oxygen, iron(II), and sulfide measured as part of geochemistry studies (Section 5.1.1) will indicate if this is reasonable over short time scales of days at the Seaplane Lagoon. The lead-210 profile will indicate if surface sediment mixing is happening on longer time frames. If substantial surface sediment mixing is found, an added parameter will be required for a mixed depth correction in the calculations for the sediment profile as has been used in previous investigations (Christensen, 1982).

Status of the Method. Lead-210 has been used for many years in determining sediment ages and sediment accumulation rates in depositional environments (Krishnaswami et al., 1971; Koide et al., 1973; Robbins et al., 1975). The decay rate constant for lead-210 is inversely proportional to the half life and is known to better than one percent. This tool has had continued use in studies of the pollution history in estuaries and lakes for metals, pesticides, and persistent organics like PCBs (for example: Bruland et al., 1974; Edgington and Robbins, 1976; Wong et al., 1995; Latimer and Quinn, 1996).

References.

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5.5.2 Measurement of Lagoon Sediment Properties (Density, Organic Content, Void Ratio, and Compressibility)

Method. The density, organic content, and void ratio, and compressibility of sediment core samples from at least three depths in three meter sediment columns will be measured to establish these sediment properties at three locations in the Seaplane lagoon. Two locations will be at the outfalls sampled in other studies, and a third location will be selected based on the Acoustic Imaging study.

The data for compressibility and organic content of the sediments are essential for determining the potential for long term consolidation under existing conditions (that is, self weight) and for surcharge conditions should a cap be placed on the sediments (Toormans, 1996). In addition, the laboratory consolidation tests on the sediment samples used to determine the compressibility also provides information on hydraulic conductivity at different overburden stresses. These data will be used to calculate the overall sediment permeability for assessing flow of water and associated chemical transport and the potential for water transport through sediments into the Merritt Sand stratigraphic zone under a sediment cap (see also 5.5.3).

Scope of the Method. The sediment properties will be measured on 3 m core samples from three depths in the lagoon. Measurements on core segments at closer intervals will be made depending on observations of sediment character during the initial field examination and on the quality of data required for the estimating the transport process, as is more critical if the sediment is in direct contact with the Merritt Sand formation.

The consolidation tests will be performed using a constant rate of strain consolidometer with internal pore pressure measurements. Because the sediments are relatively young, the apparatus will be modified to allow measurements at very low vertical effective stresses. The organic carbon content will also be used to calculate the long term-compressibility of the sediments due to organic carbon mineralization. This information will also be used for calculating the sorption of organic chemicals in sediment.

Status of the Method. The measurement of the properties will be performed using an ASTM method (Method D2974-087). As noted above, the more recent nature of these sediments requires modification of the consolidometer and special handling of the sample to get accurate measurements. The measurements for this task will be performed in the UCB Geotechnical Laboratory under the direction of Dr. Nicholas Sitar, who is the CoPrincipal Investigator for this task. Dr. Sitar is an expert on flow in porous media, and has extensive experience in geotechnical measurements and interpretation of flow data.

References.

- ASTM Standard D 854-92, Standard Test Method for Specific Gravity of Soils.
- ASTM Standard D 2435-90, Standard Test Method for One-Dimensional Consolidation Properties of Soils.
- ASTM Standard D 2974-87, Standard Test Method for Moisture, Ash, Organic Matter of Peat and Other Organic Soils.
- Toormans, E. A. 1996. Sedimentation and Self-weight Consolidation: General Unifying Theory. *Geotechnique* 16(1), 103- 114.

5.5.3 Measurement of Seepage Fluxes in Seaplane Lagoon

Method. A study to evaluate the potential for water exchange between the Merritt Sand and Seaplane Lagoon will be conducted if the acoustic imaging task demonstrates the Bay Mud strata is not intact within the lagoon and that the above task (see 5.5.2) indicates that the sediment has a permeability that is conducive to allow water flow and chemical transport between the two water-

bearing zones. The study will consist of falling head tests in three temporary piezometers installed into the Merritt Sand strata. One piezometer will be installed near each of the outfalls, with a third piezometer placed at a midpoint in the lagoon. These data will be used to determine whether there is an upward gradient into the lagoon.

Scope of the Method. A falling head test using piezometers is a standard procedure. The criteria for installing the piezometers will be discussed and approved by the Navy before this task begins. The feasibility of installing piezometers is also contingent on the depth to the Merritt Sand zone and the depth of Bay Mud. A Bay Mud thickness of less than 1m (as will be determined from the acoustic imaging task) will be interpreted to indicate that the Bay Mud is not a competent barrier to prevent transport between the two water-bearing zones.

For these tests, it is assumed that drive-point piezometers can be temporarily installed in the lagoon. The piezometers will be placed into the Merritt Sand zone beneath the lagoon rather than at locations around the lagoon because of the uncertain depths of Bay Mud outside of the lagoon. At the request of the Navy, this task may also be coordinated with the investigations being conducted by PRC.

Status of the Method. As noted above, the use of piezometers and the falling head test for measuring hydraulic conductivity is a common practice. Procedures previously prepared by PRC will be used for this task.

5.5.4 Tidal Influence Study in Landfill Wetlands

Method. This task will evaluate the exchange of water among the bay, the West Beach Landfill area, and the adjacent Landfill Wetlands. In a preliminary phase study, three piezometers will be installed adjacent to the landfill, and the hydraulic conductivity of soils will be determined. In a second phase study, the surface water levels in the ponded areas and in the piezometers and monitoring wells will be measured over a 48-hour period following a high tide episode. These data will then be used to assess whether water from within the landfill may be exchanging with ponded water in the wetlands and/or the Bay waters. This information is critical for understanding chemical transport among these water bodies.

Scope of the Method. There is currently no information to conclude whether there is exchange of water between the landfill and the Bay, or between the Bay and wetlands other than by the culvert in the western seawall. This task represents an empirical approach to evaluate whether chemicals in groundwater in the landfill or in the wetlands may migrate into the Bay through fill soils and or gaps in the seawall bordering the southern, western, and northern edges of NAS Alameda. Although some tidal influence measurements have been made in the area of Site 2, the nature of the fill material composing the seawall and also the levee separating the landfill and wetlands leaves the possibility of localized conduits for water transport through the seawall or at the seawall/Bay Mud contact. This empirical approach is a "full scale" dynamic experiment to determine whether the landfill is isolated from the wetlands and Bay with regard to chemical migration pathways.

Installation of drive-point piezometers in the Wetlands area adjacent to the West Beach Landfill is expected to be a relatively straightforward process in the shallow soils, and falling head tests will be performed according to established procedures. For the Landfill Wetlands study, water levels in surface gauges, piezometers and monitoring wells will be measured over a 48-hour period, which is believed to be sufficient on a practical time scale. Water level decreases in the wetlands will be corrected for evapotranspiration. The data collection and interpretation will be performed under the supervision of the Co-Principal Investigators, Dr. Nicholas Sitar and Dr. James Hunt, who have extensive experience in groundwater flow, hydrology, and chemical transport processes.

Basis for the Method. As discussed above, the basis for conducting the proposed study is a large scale empirical approach to evaluate the dynamics of water exchange among the landfill, wetlands and bay. This task will be conducted and results evaluated by Co-Principal Investigators in terms of flow models, flow in porous media, and geotechnical evaluations.

5.6 INTRINSIC TRANSFORMATION PROCESSES

The occurrence of intrinsic transformation processes in Seaplane Lagoon sediments and in West Beach Landfill Wetlands sediments and soils will be evaluated using several complementary approaches. The lines of evidence for intrinsic processes include fingerprinting PAH and PCB mixtures in the sediment column and in simulated sediment and soil systems, and the use of isotopes for characterizing sources and microbial pathways. The sediment column depth profiles will be compared to the lead 210 profiles to establish the time periods of deposition and, therefore, the rates of the transformation processes. The intrinsic process of methane generation in lagoon sediments will be measured for potential use in the design of a sediment cap.

5.6.1. Fingerprinting PAHs, PCBs, Hydrocarbons, and Hydrocarbon Tracers

Method. This task will develop depth profiles of PAHs, PCBs, petroleum hydrocarbons, and naturally occurring tracer chemicals to characterize the depth distribution of these chemical groups and evaluate the extent of transformations that have occurred under intrinsic conditions. Sediment core segments will be analyzed for these constituents at 20 cm intervals over a total core depth of three meters. As discussed in Section 2.0, limited data are available on the depth distribution of organic contaminants in the Seaplane Lagoon, and no information is available on the rates of the intrinsic transformations of PAHs and PCBs in lagoon sediments. Gas chromatography (GC) fingerprinting methods will be used to analyze for specific chemicals within the sediment profile.

The information from this task will complement that on microbial activity and isotopic analysis to evaluate microbial transformation of contaminants; the LBNL analytical laboratory and methods used in this task will also be used for analyses of PAHs and PCBs in the subsequent intrinsic transformation studies. The fingerprinting tools will also be applied to sediment in the West Beach Landfill Wetlands to look for evidence of leaching and biotransformation of these chemicals. The data reported for the Seaplane Lagoon sediments by PRC indicates that there should be sufficient concentrations of chemicals present to identify PCB congeners to quantify transformations over time periods of 20 to 50 years. Data for petroleum hydrocarbons, natural tracers, PAHs, and PCBs will be presented in the units of mass per gram of dry sediment.

Scope of the Method. The analytical data developed for the Seaplane Lagoon sediments will provide input to simple models for assessing contaminant alteration within the sedimentary profile. The following sections describe the data that will be collected, precedents for such studies in the literature, and how the data will be analyzed for this project.

Petroleum Hydrocarbon Analyses. Hydrocarbon properties change regularly within a class of structures (alkanes, single ring aromatics, polycyclic aromatics), and these properties control the relative reactivities and transport of chemicals within a class. It is expected that the alkane class will dominate the petroleum hydrocarbon released into the lagoon. These hydrocarbon chemicals, as analyzed by GC, will be broken down into carbon fractions such as C10 to C14, C15 to C19, C20 to C24, etc., to assess source terms and evidence of weathering and microbial transformations. The GC fingerprint will indicate the origin of the petroleum hydrocarbons and their alteration by weathering and microbial degradation as described by Bruce and Schmidt (1994). Additionally, petroleum hydrocarbons include naturally-occurring tracers that are more recalcitrant towards biotransformation than the bulk material composed primarily of normal alkanes. Early hydrocarbon

fingerprinting studies utilized the isoprenoids pristane and phytane as tracers present in crude oils, although they were observed to degrade aerobically after one year (Gundlach et al., 1983). More recently, hopanes have been shown not to degrade over six months in laboratory experiments (Prince et al., 1994). Wang et al., (1995) demonstrated the application of this technique to a crude oil spill in the Arctic that had been weathering and degrading for 12 years. For this task, hopanes will be identified to see if they are a useful monitor of hydrocarbon disappearance by microorganisms within Seaplane Lagoon and sediments upland of the Landfill Wetland.

A few examples are useful to illustrate the approach to contaminant fingerprinting. Consider three sediment samples that contain petroleum hydrocarbons and the tracer, hopane, as follows:

Sample No.	Depth	Age (Yr)	Petroleum Hydrocarbon (mg/kg)	Hopane (mg/kg)	Ratio Hopane/Petroleum Hydrocarbon
1	surface	0-5	10,000	0.10	10^{-5}
2	midpoint	20-25	15,000	0.15	10^{-5}
3	deep	40-45	20,000	0.20	10^{-5}

Here the total hydrocarbon and hopane concentrations vary with depth, but their ratios are the same indicating no selective removal of the hydrocarbons compared to hopane. This indicates that there is no microbial transformation of the hydrocarbons in the sediment core.

Another scenario is as follows:

Sample No.	Depth	Age (Yr)	Petroleum Hydrocarbon (mg/kg)	Hopane (mg/kg)	Ratio Hopane/Petroleum Hydrocarbon
1	surface	0-5	10,000	0.10	10^{-5}
2	midpoint	20-25	15,000	0.30	2×10^{-5}
3	deep	40-45	20,000	0.80	4×10^{-5}

In this example, the hopane to hydrocarbon ratio increases with depth, indicating that the hydrocarbons are being degraded if hopane is a conservative tracer. For sample 2, the hopane to hydrocarbon ratio is twice what it is in the near-surface sample indicating that sample location 2 started out 20 years ago with twice the current hydrocarbon concentration. Forty years ago, the deepest and oldest sediment was at the surface and its initial hydrocarbon concentration was four times the current amount. This data set is thus consistent with a low-level degradation rate for hydrocarbons having a half life of 20 years.

The final example for hydrocarbon tracers will be for the following possible data:

Sample No.	Depth	Age (Yr)	Petroleum Hydrocarbon (mg/kg)	Hopane (mg/kg)	Ratio Hopane/Petroleum Hydrocarbon
1	surface	0-5	10,000	0.10	10^{-5}
2	midpoint	20-25	15,000	0.30	2×10^{-5}
3	deep	40-45	20,000	0.40	2×10^{-5}

This example is the same as above for the surface and mid-depth samples, indicating a 20 year half-life for the hydrocarbons. The deep sample at an age of 40 years shows the same hopane to hydrocarbon ratio as the middepth sample, and indicates no further hydrocarbon degradation has happened. A better interpretation for this data set is that the hydrocarbons are being degraded in the

near-surface layer where redox conditions are more favorable for degradation. The actual thickness of this layer would be assessed through samples collected in the intermediate depth layers having ages between 5 and 20 years.

PAH Analyses. PAH concentrations will be measured by GC, and ratios of concentrations among PAH constituents and for PAH to total hydrocarbons will be calculated to obtain evidence of different contamination sources and for selective microbial oxidation. The PAHs have several sources such as crude oil residues (as present in Bunker C fuel), used crankcase oil, and combustion sources. As with aliphatic components of crude oil, there are PAH components that have been used as indicators of PAH origin. For example a ratio of phenanthrene to anthracene greater than 50 is representative of fresh Number 2 fuel oil while a ratio around 8 indicates used crankcase oil (Latimer and Quin, 1996).

Recent reports have noted that naphthalene and phenanthrene were oxidized to carbon dioxide under sulfate reducing conditions in contaminated sediments from San Diego Bay (Coates et. al., 1996). Other studies have demonstrated that the more soluble PAHs are preferentially biotransformed. Slurried experiments found the first evidence for this transformation when labeled compounds were added to the sediment. In partial support of this approach, Erickson et. al. (1993) found that addition of naphthalene and phenanthrene to contaminated soil resulted in rapid aerobic degradation, while the PAHs originally found in the soil were unavailable for microbial degradation. The paper by McGroddy et al. (1996) shows that PAHs are unavailable for desorption and therefore are not readily biodegradable. A focus of the PAH studies will examine a possible shift from light to heavy PAHs with depth being caused by dissolution and degradation of the lighter molecules such as naphthalene.

PCB Analyses. The data analysis for PCBs will be potentially complex since PCBs can exist in 209 different congeners - a biphenyl group with anywhere from 1 to 10 chlorines attached in various locations. The interest in specific PCB congeners is that toxicity and transport are functions of the number and placement of chlorines on the biphenyl backbone. The most toxic congeners contain two para and at least two meta chlorines. In general there is a trend for highly chlorinated PCBs to be dechlorinated to lesser chlorinated PCBs under anaerobic conditions. This has a net reduction in toxicity since a decrease in chlorination correlates with a decrease in toxicity (Abramowicz, 1990). There is evidence in the literature that the more chlorinated PCBs can be dechlorinated to less toxic forms in anaerobic freshwater and estuarine sedimentary environments (Abramowicz, 1990; Brown et al., 1987; Brown and Wagner, 1990; Lake et al., 1992; Alder et al., 1993; Ofjord et al., 1994; Bedard and May, 1996). The less highly chlorinated PCB congeners can then be aerobically degraded.

Most research on PCB dechlorination has been conducted on freshwater sediments where anaerobic conditions promote methane generation. There is some uncertainty in the scientific community whether PCB dechlorination can occur under sulfate reducing or methanogenic conditions in marine systems. Lake et al. (1992) show evidence of PCB dechlorination in New Bedford Harbor sediments and arrived at half lives of 4 to 19 years for specific congeners, but the authors did not indicate if the sediments were sulfate reducing or methanogenic. Alder et al. (1993) detected no PCB dechlorination under sulfate reducing conditions while Ofjord et al. (1994) did observe 7 to 8 percent dechlorination over a one year period in the presence of sulfate. Bedard and May (1996) report parent PCB congeners in sediment samples decreased by 5 to 14.6 mole percent and the presumptive dechlorination products increased by 4.5 to 13.0 mole percent, demonstrating an excellent balance of reactants and products. These studies have shown Aroclor 1260 breakdown congeners in a natural sediment and identified congener degradation sequences useful for reconstructing the initial composition and the extent of degradation. Sokol et al. (1994) have reported that Aroclor 1248 has been partially dechlorinated in the sediments from two locations of the St. Lawrence River.

Abramowicz et al. (1993) reported that PCB degradation rates increased linearly with PCB concentration over the range of 0 to 250 ppm. On the other hand the results of Sokol et al. (1994) show reductive dechlorination of PCBs in Saint Lawrence River sediments, but find the extent of dechlorination is highly variable within a small area. The authors suggest that in situ dechlorination was inhibited by high levels of metals and/or PAHs (greater than 5000 mg/kg). This could be a concern in the Seaplane Lagoon where high concentrations of metals have been reported.

Given the existence of PCBs in the Seaplane Lagoon sediments at greater than part per million levels, the studies will look for evidence of long-term transformations in the age-dated profile similar to those reported in literature. An example is shown below demonstrating how rates can be obtained from the sediment record when only two congeners, trichloroPCB and hexachloro-PCB are considered:

Sample	trichloro-PCB	hexachloro-PCB
Original PCB	20%	80%
Sediment PCB	60%	40%

Based on the history of PCB usage, the initial congener composition within the PCB is assumed known and sediment data show the final composition after 40 years of burial. Given that half of the hexachloro-PCB has been transformed to trichloro-PCB in 40 years the half life for this reaction is 40 years. Since spilled PCBs are more complex than the above example illustrates, looking for evidence of transformation in the sediment profile is one method of determining in-situ rates when the rates are very slow, such as when half-lives greater than 5 years.

Status of the Method. Analyses of PCB and PAHs will use standard analysis methods, likely modified with the use of different temperature programs to achieve better separation of constituents. Hopanes have been used along with other compounds for tracing the extent of crude oil biodegradation in natural environments. Data on PAH biodegradation in marine sediments is scarce. PCB dechlorination reactions have also been studied in the Hudson River by General Electric Company where they showed that the reactions are relatively slow. The PCB analysis approach used in these studies will follow the previous studies and is expected to provide bounds on in-situ transformation rates in lagoon and wetland sediments.

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5.6.2 Sources of Transformation Products Using Isotope Measurements

Method. Measurements of the carbon isotope compositions of dissolved methane and dissolved inorganic carbon (DIC) in the sediment pore waters from the Seaplane Lagoon will be used to determine if these products of carbon mineralization are derived from the intrinsic biotransformation of petroleum materials previously released into the lagoon. The isotope measurements will be performed on sediment core segments taken from a 3 m core near an outfall. In a similar study for the Landfill Wetlands, the carbon isotope compositions of methane and DIC in ground water and porewaters will signify whether petroleum materials are the source of these metabolites; isotopic measurements of carbon dioxide and possibly methane in soil gases from the vadose zone soils will provide information to complement the isotope analyses for water samples. The nitrogen isotope ratios in Landfill Wetland pore waters will also provide information on possible anthropogenic sources of nitrogen (such as munitions chemicals) from the landfill.

The carbon isotope ratio data from these studies will demonstrate whether intrinsic biotransformation of petroleum hydrocarbons is occurring in Seaplane Lagoon sediments, and provide some indication of the microbial processes that occur in the sediments. The carbon isotope measurements on organic carbon in the sediment will also determine the amount of petroleum material present compared to the more recent natural organic material. Isotope ratios for carbon dioxide in groundwater and soil gas in the Landfill Wetlands area will also be used to assess migration of petroleum transformation products from the landfill.

Scope of the Method. At NAS Alameda, radiocarbon (^{14}C) measurements are particularly well suited for determining the contribution of petroleum hydrocarbon compounds to the carbon budget in sediment. ^{14}C is a radioactive isotope of carbon produced by interaction of cosmic rays with the upper atmosphere. Because of the relatively short half-life of ^{14}C (5730 years), it is essentially undetectable in fossil carbon sources, such as crude oil and petroleum products, formed more than 60,000 years ago. All the other potential sources of carbon at NAS Alameda (natural soil organic matter, carbonate shells, atmospheric carbon dioxide) are relatively recent and have near modern levels of ^{14}C (Conrad et al., 1995).

The stable carbon isotope ratios ($^{13}\text{C}/^{12}\text{C}$) will also aid in differentiating the sources of methane and DIC, and will be useful for distinguishing the dominant microbial processes controlling their concentrations in the sediments (e.g., methanogenesis, methane oxidation). These processes cause distinctive shifts (or fractionations) in the $^{13}\text{C}/^{12}\text{C}$ ratios of the compounds produced. Coupling the $^{13}\text{C}/^{12}\text{C}$ data with the ^{14}C data (which are essentially unaffected by the fractionating effects of these processes) will make it possible to separate the effects of the microbial processes from the effects of diffusion.

Isotope ratios in groundwater from the Landfill Wetlands and downgradient areas will be used to assess the possible presence of migrating chemicals toward the wetlands from the landfill. The nitrogen isotope ratios ($^{15}\text{N}/^{14}\text{N}$) of different potential sources for groundwater nitrate (e.g., plant matter, fertilizers, munitions such as TNT, sewage waste) can often be resolved by their nitrogen isotope signature (Chapelle, 1993). The initial oxygen isotope ratios ($^{18}\text{O}/^{16}\text{O}$) of nitrate are predictable (resulting from a combination of groundwater and atmospheric oxygen). Use of nitrate for microbial metabolic processes causes both the $^{15}\text{N}/^{14}\text{N}$ and $^{18}\text{O}/^{16}\text{O}$ ratios of the residual nitrate to be shifted (fractionated) towards higher values. The combination of these two measurements can be used to help determine both the source of the nitrate and the degree of microbial utilization of the nitrate (Kendall et al., 1993). These measurements will provide data for evaluating the fate of nitrogen-bearing compounds in the landfill and the degree to which microbial activity is limited by the supply of nitrogen.

Status of the Method. The use of isotope measurements for assessing chemical sources and processes is reported in the geochemical literature, but the application of these methods is limited by the expertise and analytical equipment required for making the measurements and interpreting the analytical data. The measurements for this task will be performed at the Center for Accelerator Mass Spectrometry at LLNL. Collection of samples, preparation of the samples for analysis, and the isotopic measurements will be supervised by Dr. Mark Conrad of LBNL; Dr. Conrad has extensive experience for the proposed studies, including studies conducted at NAS Alameda.

References.

- Chapelle, F.H., 1993, *Ground-Water Microbiology & Geochemistry*. John Wiley & Sons, Inc., New York, 424 p.
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- Kendall, C., Silva, S.R., Chang, C.C., Campbell, D.H., Burns, D.A., and Shanley, J.B., 1994, Use of Oxygen and Nitrogen Isotopes to Trace Sources of Nitrate in Hydrologic Systems. EOS, Transactions, American Geophysical Union, v. 75, n. 44, p. 279.

5.6.3 Intrinsic Production of Methane in Anaerobic Lagoon Sediments

Method. This task will assess the rate and volume of methane produced in sediment from the Seaplane Lagoon. The methane production will be measured for 20 cm segments taken from a 3 m

core from the lagoon. This information is important for the design of a sediment cap that is a potential remedial option for the Seaplane Lagoon and to assess the presence of methane that may promote anaerobic alteration of PCBs. The evolution of methane from Landfill Wetlands will not be evaluated because there are no plans for the wetlands area to be capped.

Scope of the Method. The production of methane from sediments is a well recognized process. Although the production of methane in the Seaplane Lagoon has not been documented, it is expected that at some depth in the sediment column the system is methanogenic (that is, methane generating). It is likely that the Holocene Bay Mud is also methanogenic. The production of methane from 20 cm intervals over a 3m column will be measured to determine the depth at which methane is generated, and the amount of methane generated at successively greater depths. The production of methane is of concern because the rate and amount of methane production must be known to assess the feasibility of a sediment cap and to design the cap.

Status of the Method. The procedure to be used is based on a method (Simbert and Krieg, 1994), and is discussed in the SAP.

References.

Simbert, R.M., and N.R. Krieg. 1994. Phenotypic Characterization. In: Methods for General and Molecular Bacteriology. Gerhardt, P., R.G.E. Murray, W.A. Wood, N.R. Krieg (eds), pp. 631-632. American Society for Microbiology. Washington, D.C.

5.6.4 Intrinsic Transformation of PAHs and PCBs in Anaerobic Lagoon and Wetland Sediments.

Method. This task will evaluate the intrinsic biotransformation of PAHs and the PCB congeners that are present in anaerobic saturated sediments in the Seaplane Lagoon and Landfill Wetlands. The results of this experiment will be used to estimate the rates of transformations of PAH and PCB chemicals in saturated anaerobic sediment systems maintained under simulated natural conditions in the laboratory. Anaerobic systems will be reestablished in the laboratory using anaerobic sediment segments from the 0.5 m to 1.0 m depths of sediment cores collected from one location in the Seaplane Lagoon and from one location in a ponded area of the wetland.

The intrinsic property of the sediments will be defined by using site sediments maintained under anaerobic conditions and without adding any nutrients or study chemicals (PCBs or PAHs). The anaerobic system will be undisturbed except for mixing under anoxic conditions prior to sampling (see below). The concentrations of PCB congeners and selected PAHs will be measured after periods of 3 months and 6 months to evaluate the rate at which these chemicals are being transformed. The specific PAH and PCB chemicals studied will be determined based on the concentrations measured in the initial analyses.

Scope of the Method. The primary intrinsic transformation experiment will be conducted in a batch reactor to simulate anaerobic sediment conditions where PAHs and PCBs are already present. This experimental design will use sediments preserved and maintained in an oxygen-free system, with a total of four batch reactors (two sets of two) prepared with the sediments thoroughly mixed in the reactor to minimize heterogeneity in sampling of constituents. Each anaerobic system will be stirred thoroughly prior to each sampling event (at initial setup, 3 months, and 6 months) to minimize sampling heterogeneity. It is expected that any minor disturbances in sediment chemistry due sample collection and transfer will be effectively buffered by the existing properties of the sediment. Three samples will be collected from each reactor and analyzed to represent the initial concentrations at time zero ($t=0$). Subsequently, each set of reactors will be sampled after 3 months and 6 months, with collection and analyses as described above.

The above experimental design recognizes that significant transformation of some PAHs and PCBs has already occurred, and that the saturated, anaerobic sediment reactors simulate environmental conditions. The design overcomes the initial heterogeneity of chemical distribution, and assumes that the system maintained under initial anaerobic conditions can exhibit further transformations of the remaining PAHs and PCBs. To avoid pressure buildup due to carbon dioxide and methane formation in the sediments, a mixture of carbon dioxide, hydrogen and nitrogen will continuously purge the reactor headspace at a slow rate to prevent gas accumulation and maintain the anaerobic conditions. As measures of the consistency of reactor conditions, the redox potential of overlying water will be measured on a weekly basis.

Basis for the Method. The method reflects an empirical approach where losses of PAH and PCB chemicals present in anaerobic sediments will be monitored. The use of static systems for such experimental conditions is frequently reported in literature. In this set of experiments, variables such as carbon dioxide production and redox potential of overlying water will be measured to assess system constancy.

5.6.5 Constraints on Microbial Transformations of PAHs and PCBs in Lagoon Sediments.

Method. This task will evaluate the constraints associated with selected environmental variables on the microbial transformation rates of PAHs and PCBs in sediments from the Seaplane Lagoon; the environmental variables to be assessed in these studies include sulfate, nitrate, and oxygen; a control with no amendments will also be conducted with the expectation that the system will be methanogenic. The experiments will be continuously stirred and with periodic addition of sulfate, nitrate and oxygen to maintain the system under conditions that simulate conditions in the respective electron-acceptor controlled layers in the intrinsic sediment condition.

The studies are intended to provide transformation rate data that can be used to estimate the persistence of PAHs and PCBs in the Seaplane Lagoon. These studies will use an unweathered PCB mixture and ^{14}C - radiolabeled PAHs to assess the relative rates of transformation. Transformation of PAHs evaluated in terms of ^{14}C -carbon dioxide evolution and PAH loss also measured as incorporation of the ^{14}C -label into the sediment organic matrix and into soluble organic constituents that represent transformation products. The effects of alternate electron acceptors (such as sulfate and nitrate) are important for understanding how PAH and PCB transformation rates vary in sediment, and to obtain preliminary data for use in designing treatability studies to enhance remediation of organic chemicals in sediments. The data from the unamended stirred reactor will also be compared to the unstirred reactor system (5.6.4) to compare reactor conditions and transformation rates of selected PAH and PCB constituents.

Scope of the Method. The experiments are planned to assess the influence of electron acceptors in promoting oxidation of PAHs and PCBs in saturated sediments. It is recognized that the PAH and PCB structures that currently are present in sediments may be inherently more resistant to transformation. Therefore, it is informative to compare how the transformation rates of an unweathered PCB mixture and selected PAHs are affected in controlled redox sediment systems. If losses of PCBs are observed, the PCB congeners will be analyzed and the congener distributions compared to the congeners that are currently present in sediments (see 5.6.1).

Status of the Method. A number of laboratory studies have been conducted to show that electron acceptors can promote transformations of PAHs and PCBs, but these studies have often used forcing conditions that are of questionable relevance to the rates that will occur in actual sediment systems. Data from the experiments in the proposed study will be used in designing field monitoring programs and laboratory studies to more accurately assess intrinsic rates in anaerobic sediments.

References.

- Coates, J.D., R.T. Anderson, and D.R. Lovley. 1996. Oxidation of Polycyclic Aromatic Hydrocarbons under Sulfate-Reducing Conditions. *Applied and Environ. Microbiology*. 62(3): 1099-1101
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5.6.6 Transformation of PCBs and PAHs in Vadose Zone Soil Plots

Method. This task will assess conditions influencing the transformation of PAHs and PCBs in vadose zone soils in the West Beach Landfill Wetlands area. The studies will use field plots of one square meter each established in an area of the Landfill Wetlands adjacent to the landfill where the highest concentration of PAHs and PCBs have been detected. One plot (A) will be maintained under existing conditions, except for an initial thorough mixing of soil as discussed below. Another set of two experiments (two plots, B and C) will add selected PAHs to the soil to increase the PAH concentrations that will assure the capability of measuring PAH losses from the soil plots over the 6-month duration of the field experiments. The fourth plot (D) will be prepared in an identical manner to Plot A except that Plot D, as well as Plot B, will be planted with indigenous vegetation to simulate the rhizosphere in the wetland. As controls on the contribution of plant growth to transformation of PAHs, Plots A and C will be periodically weeded as necessary. The experiments will be conducted on initially well-mixed soils to minimize PAH and PCB concentration variability associated with soil heterogeneity and uneven chemical distribution in soils. The concentrations of PAHs, including the added PAH, and PCBs will be measured in soil samples collected at 3-month and 6-month intervals.

These studies will evaluate the effect of vegetation growth on the transformation rate of PAHs and PCBs in wetlands soils, and provide an overall assessment of the transformation rates of PAHs and PCBs under actual field conditions. Although the soils will be thoroughly mixed to minimize chemical distribution heterogeneities due to source or deposition differences, some variability in sample composition is expected due to soil grain size effects. These experiments will allow for an assessment of chemical distribution uncertainties that can then be used for future risk assessment and potential remediation evaluations.

Scope of the Method. The proposed studies represent an empirical approach to evaluate the persistence of PAHs and PCBs under actual environmental conditions. As discussed below, the heterogeneities of the site soils is a major issue for design of such experiments in the vadose zone where chemical transport of non-volatile chemicals is limited. The expertise and professional judgment of the Co-Principal Investigator will be critical in the setup, monitoring, and evaluation of the results of these experiments.

The limitations on the design of intrinsic remediation studies include the potentially fragile nature of the vadose zone soil regime toward artifacts due to sampling and handling (exposure to oxygen, breakup of soils), and the unknown effects of seasonal inputs (temperature, rainfall, nutrient input, inundation). Previous PRC investigations of PAHs and PCBs in soil in the Landfill Wetlands used a 200-ft grid spacing, and found that the highest concentrations of PAHs and PCBs are adjacent to the landfill (see Section 2). However, PCBs and PAHs are also present at slightly lower concentrations (by 2 to 20 times) throughout the Landfill Wetlands, and which may have been present on soils used as fill in this area. The existing distribution of PCBs and PAHs at levels near reporting limits are especially problematic in planning an intrinsic remediation study when the losses of chemical concentrations are monitored. This is because potentially large variances in concentrations require a very large number of analyses so as to provide statistically meaningful loss rates. Such experimental problems are expected to be lessened when the system can be made less heterogeneous by mixing of soil in controlled plots.

Status of the Method. The proposed studies are designed for simulate actual environmental field conditions with soil thoroughly mixed to minimize sample heterogeneity.

References.

- Hunt, Jr.R., P. A. Holden, and M. K. Firestone. 1995. Coupling Transport and Biodegradation of VOCs in Surface and Subsurface Soils. *Environmental Health Perspectives* 103 (Supplement 5), 75-78.
- Holden, P. A., and M. K. Firestone. 1996. Soil Microorganisms in Soil Cleanup: How Can We Improve Our Understanding? In press, *J. Environ. Qual.*
- Qiu, X., S. I. Shah, E.W. Kendall, D.L. Sorensen, R. C.Sims, and M.C. Engelke. 1994. Grass-enhanced Bioremediation for Clay Soils Contaminated with Polynuclear Aromatic Hydrocarbons. In: *Bioremediation through Rhizosphere Technology*. Ed. T.A. Anderson and J.R. Coats. ACS Symposium Series 563, Washington D.C.

5.7 PROCESSES IN DISTURBED SEDIMENT SYSTEMS

The studies described below address conditions that may result from sediment disturbance due to remediation or other activities. Such disturbance could expose the anoxic sediment to atmospheric oxygen, and thereby cause chemical changes in the sediment composition. The studies proposed are to evaluate the effect of such processes on leachate from such sediments that would be disposed on the land surface and subjected to rainfall infiltration disposal.

5.7.1 Leachate Characterization from Disturbed Lagoon Sediments

Method. The following experiment will be conducted on contaminated sediments from the Seaplane Lagoon to determine the rates and concentrations at which metal contaminants are released into the aqueous phase. The experiments will be performed in flow-through reactors at room temperature (Knauss and Wolery, 1986). Several leaching experiments (2 to 4 experiments) are planned to evaluate reproducibility with the leachate concentrations of Cd, Cr, Cu, Hg, Ni, Pb, and Zn measured for a 90 day period.

Scope of the Method. These experiments will provide leaching rates that can be applied to a remediation scenario that involves placing Seaplane Lagoon sediments on land. The leaching solution will consist of distilled/deionized water equilibrated with atmospheric oxygen and carbon dioxide, which then simulates rainwater. At the completion of these experiments, the solids will be freeze dried and ground for XAS (see 5.2.4) to determine if the metal speciation in the solids phase was changed during the leaching experiment. This information is valuable for understanding the leaching experiments, because it is likely that metals that are stable in anoxic sediments will dissolve and then sorb onto or react with other solid phases in oxic sediments. If this is the case, then the long-term hazard of the metals may be significantly limited, because the metals will be associated with solid phases in both environments. Details of the expected range of values, reporting/detection limits, and possible interferences of the specific analytical techniques is discussed in the SAP.

In these experiments the rate of metal leached is proportional to the change in concentration between the input and output solutions. All rates will be normalized with respect to total mass of sediment and possibly the initial concentration of metal contaminant. The duration of the leaching experiments will be a total of 3 months (see SAP). The solution pH and total metals will be analyzed according to the procedures described above (see 5.2.2). XAS results will report the atomic structure of the contaminant including metal oxidation state and the phase in which the metal is bonded.

The application of these rates are specific to Seaplane Lagoon sediments disposed in an oxidizing environment. It is assumed that leaching of metals from the solid phase is controlled by reactions at the sediment/porewater interface. The XAD analysis information at the end of the 3 month leaching experiment will be evaluated for the potential for longer term leaching of metal constituents.

Status of the Method. The use of flow-through reactors is a routine method for determining leaching or dissolution rates that are controlled by reactions occurring at solid-solution interfaces (see Sampling and Analysis

Plan). Leaching experiments comparable to the proposed studies have been conducted by the Co-Principal Investigator, Dr. Susan Carroll of LLNL, and who will supervise these studies.

Reference.

Carroll, S.A., and Bruno, J., (1991). Mineral-solution Interaction in the U(VI)- CO₂-H₂O System. *Radiochimica Acta*, 52/53, 187-193.

Knauss K. and Wolery, T.J. (1986) Dependence of Albite Dissolution Kinetics on pH and Time at 25 and 70°C. *Geochemica Cosmochimica Acta*, 50, 2481-2497.

5.7.2 Toxicity of Disturbed Sediments

Method. This study utilizes the Sediment/Water Interface Core (SWIC) test procedure (see 5.3.2) with a modification that air is passed through a sparger placed beneath the sediment core, thereby disturbing and aerating the sediment core in the presence of the test species. The test species used will be the same as used for the developmental and survival tests (see 5.3.1). The disturbed sediment SWIC tests will be conducted using surface and one subsurface core segment from the same stations as tested in the intact core SWIC test.

The results of these tests will be used to evaluate the toxicity associated with sediment disturbance. The test results will also be compared to the SWIC tests using the undisturbed cores, and the data for the AVS/SEM tests will also be used to determine the contribution of metal toxicity to the disturbed sediment test results.

Scope of the Method. This procedure is a straightforward modification of the SWIC test (see 5.3.2) that provides important information on the effects of aeration of sediment on ecotoxicity. This test is designed to be optimally comparable to the other sediment exposure tests performed to evaluate intrinsic sediment conditions. The test method is regarded as an innovative approach and a modification of a method that has been previously developed and applied by the Co-Principal Investigator, Dr. Susan Anderson of LBNL. This test will be conducted at LBNL under the supervision of Dr. Anderson. The report for this study will present test results as well as a discussion of how these results are expected to simulate actual site conditions.

Status of Method. As stated above, the proposed test for disturbed sediment toxicity is a modification of the SWIC test. The test will be performed under the direct supervision of the Co-Principal Investigator to optimize the relevance and interpretation of the result for the project objectives.

**TABLES
&
FIGURES**

Table 5-1
Summary of Sampling and Analysis Plan
Seaplane Lagoon (Site 17)
 (page 1 of 2)

Physical Characterization of Sediment			
Task	Sample Media	Information to be Obtained	Reference Section
Acoustic Imaging	In-situ measurements	Stratigraphic profiles and detection of gas pockets in sediment	5.1

Chemical Characterization of Pore Water and Sediment			
Task	Sample Media	Information to be Obtained	Reference Section
Microelectrode Measurements in Sediment Core Pore Waters	Sediment core to 20 cm	Concentrations of dissolved oxygen, iron-II, manganese-II and total sulfide as well as pH	5.2.1
Pore Water Constituent Measurements	Pore water from sediment core to 50 cm	Concentrations of soluble anions, major and trace metals	5.2.2
Sediment Bulk Mineralogical and Chemical Analyses	Sediment core to 2 m	Concentrations of trace metals and bulk soil mineralogy	5.2.3
Sediment Metal Speciation Analyses	Sediment core to 2 m	Speciation of major metal phases	5.2.4

Pore Water and Sediment Toxicity Tests			
Task	Sample Media	Information to be Obtained	Reference Section
Surface Sediment Pore Water Toxicity Test	Pore water extracted from surface sediment	Developmental and survival toxicity from exposure to surface pore waters	5.3.1
Surface Sediment/Water Interface Corer (SWIC) Test	Surface sediment core	Developmental and survival toxicity from exposure to surface sediment core	5.3.2
Subsurface Sediment/Water Interface Corer (SWIC) Test	Sediment cores at both 1 m and 2 m	Developmental and survival toxicity from exposure to surface sediment core	5.3.2
Pore Water Toxicity Identification Evaluation (TIE)	Pore water extracted from surface sediment	Evaluate toxicity due to ammonia and sulfide, dissolved metals, and/or organic constituents	5.3.3
Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metal (SEM)	Acid solution extracted from surface sediment core and sediment cores at both 1 m and 2 m	Sulfide and metal concentrations in sediments to predict toxicity associated with bioavailable metals	5.3.4

Bioavailability Evaluation			
Task	Sample Media	Information to be Obtained	Reference Section
Bivalve Test	Surface sediment core and sediment cores at both 1 m and 2 m	Concentrations of SVOCs in tissue from exposure to sediment core	5.4.1
Digestive Fluid Extraction	Surface sediment core and sediment cores at both 1 m and 2 m	Concentrations of SVOCs in digestive juices from exposure to sediment core	5.4.2

Table 5-1
Summary of Sampling and Analysis Plan
Seaplane Lagoon (Site 17)
 (page 2 of 2)

Transport Processes Assessment			
Task	Sample Media	Information to be Obtained	Reference Section
Lead-210 Profile in Sediment	Sediment core to 3 m	Concentrations of lead-210	5.5.1
Measurement of Lagoon Sediment Properties	Sediment core to 3 m	Data for density, organic content, void ratio, and compressibility	5.5.2
Measurement of Seepage Fluxes in Seaplane Lagoon (if applicable)	In-situ measurements	Determination of upward hydraulic gradient into Seaplane Lagoon	5.5.3

Intrinsic Transformation Processes			
Task	Sample Media	Information to be Obtained	Reference Section
Fingerprinting of PAHs, PCBs, Hydrocarbons and Hydrocarbon Tracers	Sediment core to 3 m	Identification of PAH constituents, PCB congeners, and hydrocarbon fractions	5.6.1
Sources of Transformation Products Using Isotope Measurements	Pore water from sediment core to 3 m	Carbon isotope compositions of dissolved methane and inorganic carbon in water	5.6.2
Intrinsic Production of Methane in Anaerobic Lagoon Sediments	Sediment core to 2 m	Volume and rate of methane generation	5.6.3
Intrinsic Transformation of PAHs and PCBs in Anaerobic Lagoon Sediments	Batch scale reactor using sediment core to 1 m	Rate of transformation of PAH and PCB chemicals	5.6.4
Constraints on Transformation of PAHs and PCBs in Anaerobic Lagoon Sediments	Batch scale reactor using sediment core to 1 m	Rate of transformation of PAH and PCB chemicals	5.6.5

Processes in Disturbed Sediment Systems			
Task	Sample Media	Information to be Obtained	Reference Section
Leachate Characterization from Disturbed Seaplane Lagoon Sediments	Flow thru reactor using sediment	Concentrations of major and trace metals	5.7.1
Toxicity of Disturbed Sediments	Surface sediment core as well as sediment cores at both 1 m and 2 m	Developmental and survival toxicity from exposure to surface of aerated sediment core	5.7.2

Table 5-2
Summary of Sampling and Analysis Plan
West Beach Landfill Wetlands (Site 2)
 (page 1 of 2)

Physical Characterization of Sediment			
Task	Sample Media	Information to be Obtained	Reference Section
Acoustic Imaging	In-situ measurements	Stratigraphic profiles and detection of gas pockets in sediment	5.1

Chemical Characterization of Pore Water and Sediment			
Task	Sample Media	Information to be Obtained	Reference Section
Microelectrode Measurements in Sediment Core Pore Waters	Sediment core to 20 cm	Concentrations of dissolved oxygen, iron-II, manganese-II and total sulfide as well as pH.	5.2.1
Pore Water Constituent Measurements	Pore water from sediment core to 50 cm	Concentrations of soluble anions, major and trace metals	5.2.2
Sediment Bulk Mineralogical and Chemical Analyses	Sediment core to 1 m	Concentrations of trace metals and bulk soil mineralogy	5.2.3
Sediment Metal Speciation Analyses (if applicable)	Sediment core to 1 m	Speciation of major metal phases	5.2.4

Pore Water and Sediment Toxicity Tests			
Task	Sample Media	Information to be Obtained	Reference Section
Surface Sediment Pore Water Toxicity Test	Pore water extracted from surface sediment	Developmental and survival toxicity from exposure to surface pore waters	5.3.1
Pore Water Toxicity Identification Evaluation (TIE)	Pore water extracted from surface sediment	Evaluate toxicity due to ammonia and sulfide, dissolved metals, and/or organic constituents	5.3.3
Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metal (SEM)	Acid solution extracted from surface sediment core	Sulfide and metal concentrations in sediment to predict toxicity associated with bioavailable metals	5.3.4

Bioavailability Evaluation			
Task	Sample Media	Information to be Obtained	Reference Section
Bivalve Test	Surface sediment core	Concentrations of SVOCs in tissue from exposure to sediment core	5.4.1
Digestive Fluid Extraction	Surface sediment core	Concentrations of SVOCs in digestive juices from exposure to sediment core	5.4.2

Table 5-2
Summary of Sampling and Analysis Plan
West Beach Landfill Wetlands (Site 2)
 (page 2 of 2)

Transport Processes Assessment			
Task	Sample Media	Information to be Obtained	Reference Section
Tidal Influence Study in Landfill Wetlands	In-situ measurements	Hydraulic conductivity and surface water level fluctuations	5.5.4

Intrinsic Transformation Processes			
Task	Sample Media	Information to be Obtained	Reference Section
Fingerprinting of PAHs, PCBs, Hydrocarbons and Hydrocarbon Tracers	Sediment core to 1 m	Identification of PAH constituents, PCB congeners, and hydrocarbon fractions	5.6.1
Sources of Transformation Products Using Isotope Measurements	Pore water from sediment core to 1 m; soil gases	Carbon isotope compositions of dissolved methane and inorganic carbon as well as nitrogen isotope ratios in water; carbon dioxide and methane in soil gases	5.6.2
Intrinsic Transformation of PAHs and PCBs in Anaerobic Wetland Sediments	Batch scale reactor using sediment core to 1 m	Rate of transformation of PAH and PCB chemicals	5.6.4
Transformation of PAHs and PCBs in Vadose Zone Soil Plots	Mixed vadose zone soil	Rate of transformation of PAH and PCB chemicals	5.6.6

TABLE 5.3
DATA USE OBJECTIVES FOR
INTRINSIC SEDIMENT PROCESSES STUDY
 Page 1 of 5

<u>Task/ SOP in Work Plan</u>	<u>Measurement</u>	<u>Media</u>	<u>Assessment of Migration Pathways and Toxicity</u>	<u>Evaluation of Intrinsic Remediation Processes</u>	<u>Evaluation of Issues Associated with Remedial Strategies</u>
5.2 Chemical Characterization of Porewater and Sediment					
5.2.1 Microelectrode Measurements in Sediment Core Pore Waters, SOP 26.1	Dissolved oxygen, Fe ⁺² , Mn ^{III} , Total sulfide	In-situ porewater	Describe In-situ redox conditions related to chemical speciation and sediment condition, used to understand chemical species availability	Understand electron acceptor presence and flux for biotransformation evaluations	
5.2.2 Porewater Constituents, SOP 26.2	Cl ⁻ , F ⁻ , NO ₂ ⁻ , NO ₃ ⁻ , SO ₄ ⁻² , PO ₄ ⁻³ ; Cd, Cu, Cr, Ni, Pb, Zn; Al, Ca, Fe, Na, Mg, Mn, S	Extracted porewater	Provide complete analyses of constituents in pore water, used to understand species availability and to develop geochemical model	Provide data on advective versus diffusive transport processes in deeper sediment cores; information on availability of electron acceptors in sediment layers	Apply geochemical model to estimate chemical concentrations and toxicity in disturbed sediment condition (dredging)
5.2.3 Sediment Bulk Mineralogical and Chemical Analyses, SOP 26.3	Mineralogy and morphology	Sediment	Assess sediment characteristics, used to compare/extrapolate data and method to other sites	Potentially useful for assessing sources of sediments from outfalls compared to Bay sources	Assess sediment characteristics, used to compare and potentially extrapolate data and method to other sites
	Al, Cd, Cu, Ni, Pb, Zn	Sediment	Measure solid phase constituent concentrations, used to compare with PRC data and select representative samples for measurements using SOP 26.4		
5.2.4 Sediment Metal Speciation Analysis, SOP 26.4	Redox status of Cd, Cu, Cr, Hg, Ni, Pb, and Zn	Sediment	Determine speciation of metals, used to evaluate metals availability under current and future (disturbance) scenarios, and to develop geochemical model		Apply geochemical model to estimate chemical concentrations and toxicity in disturbed sediment condition (dredging)

TABLE 5.3
DATA USE OBJECTIVES FOR
INTRINSIC SEDIMENT PROCESSES STUDY
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<u>Task/ SOP in Work Plan</u>	<u>Measurement</u>	<u>Media</u>	<u>Assessment of Migration Pathways and Toxicity</u>	<u>Evaluation of Intrinsic Remediation Processes</u>	<u>Evaluation of Issues Associated with Remedial Strategies</u>
5.3 Porewater and Sediment Toxicity Tests					
5.3.1 Surface Sediments Pore Water Toxicity Tests, SOP 27.1	Developmental toxicity to echinoderm	Extracted Porewater	Assess toxicity due to constituents in pore water		
	Survival toxicity for amphipod	Extracted Porewater	Assess toxicity due to constituents in pore water		
5.3.3 Pore Water Toxicity Identification Evaluations, SOP 27.3	Ammonia, sulfides, metals, VOC and SVOC chemicals	Extracted Porewater	Determine constituents responsible for toxicity measured in SOP 27.1		
5.3.4 Acid Volatile Sulfide/Simultaneously Extracted Metals, SOP 27.4	Sulfide and metals ratio in sediment	Sediment	Determine potential for toxicity related to metals controlled by sulfide in sediments		Assess potential for metals release after sediment oxidation in disturbed sediment (dredging)
5.3.2 Sediment/Water Interface Core Test, SOP 27.2	Developmental toxicity to echinoderm	Sediment core at surface and at depth	Assess toxicity associated with total sediment/porewater system (compared to SOP 27.1)		Assess toxicity associated with deeper sediment layers if upper layers removed by dredging
	Survival toxicity for amphipod	Sediment core at surface and at depth	Assess toxicity associated with total sediment/porewater system (compared to SOP 27.1)		Assess toxicity associated with deeper sediment layers if upper layers removed by dredging
5.4 Bioavailability Evaluation					
5.4.1 Bioavailability /Bioaccumulation by Bivalve, SOP 28.1	PAH, PCB	Tissue	Assess bioaccumulation in bivalve		Assess bioaccumulation associated with exposure to deeper sediment layers
5.4.2 Digestive Fluid Extraction, SOP 28.2	PAH, PCB	Digestive juice extracts	Measure maximum bioavailability partitioning from sediment contact with digestive juice of benthic organisms		Measure maximum bioavailability from deeper sediment exposure to digestive juice of benthic organisms

TABLE 5.3
DATA USE OBJECTIVES FOR
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<u>Task/ SOP in Work Plan</u>	<u>Measurement</u>	<u>Media</u>	<u>Assessment of Migration Pathways and Toxicity</u>	<u>Evaluation of Intrinsic Remediation Processes</u>	<u>Evaluation of Issues Associated with Remedial Strategies</u>
5.5 Transport Processes Assessment					
5.5.1 Lead-210 in Sediment, SOP 29.1	²¹⁰ Pb, ¹³⁷ Cs, ²²⁶ Ra	Sediment segments	Provide time deposition profile for sediment used to correlate with chemical concentrations; identify sediment layers containing radium from paint wastes.	Establish time profile used with SOP 30.1 to estimate PAH and PCB transformation rates	Provide guidance for limited dredging of sediment based on deposition rate and source correlation
5.5.2 Measurement of Lagoon Sediment Properties, SOP 29.2	Specific gravity; one-dimensional consolidation properties	Sediment segments	Measure properties related to water flow in lagoon; data will be used with piezometer data to estimate gradient/flow in lagoon		Estimate sediment consolidation by self-weight and under cap weight; evaluate water flow in relation to capping alternative
	Moisture, Organic Matter in Soils	Sediment segments	Measure properties related to water flow in lagoon, and for chemical partitioning between sediment and water		Estimate sediment consolidation by self-weight and under cap weight with carbon losses
5.6 Intrinsic Transformation Processes					
5.6.1 Fingerprinting of PAHs, PCBs, Hydrocarbons and Tracers in Sediment, SOP 30.1	PAHs, PCB congeners, petroleum hydrocarbons	Sediment segments	Determine transformation patterns and estimate rates of transformation in sediment, with data from 29.1	Estimate rates of transformation in sediment, with data from 29.1	
5.6.2 Isotope Monitoring, SOP 24.4					
	Ratio ¹³ C/ ¹² C in organic matter fractions, methane, carbon dioxide	soil, soil gas, water, hydrocarbon phases (as appropriate)	Provide evidence for depositional patterns or mixing in sediment layers	Provide evidence for transformation of anthropogenic hydrocarbons and transformation pathways	

TABLE 5.3
DATA USE OBJECTIVES FOR
INTRINSIC SEDIMENT PROCESSES STUDY
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<u>Task/ SOP in Work Plan</u>	<u>Measurement</u>	<u>Media</u>	<u>Assessment of Migration Pathways and Toxicity</u>	<u>Evaluation of Intrinsic Remediation Processes</u>	<u>Evaluation of Issues Associated with Remedial Strategies</u>
	Ratio D/H in methane, water, hydrocarbon phase	soil gas, water, hydrocarbon phases (as appropriate)	Provide evidence for depositional patterns or mixing in sediment layers	Provide evidence for transformation of anthropogenic hydrocarbons and transformation pathways	
	Ratio ¹⁵ N/ ¹⁴ N in soil organic material and nitrate	soil and water (as appropriate)	Provide evidence for depositional patterns or mixing in sediment layers	Provide evidence for nature of transformation pathways	
	Ratio ¹⁸ O/ ¹⁶ O in soil organic matter, nitrate and water	soil and water	Provide evidence for depositional patterns or mixing in sediment layers	Provide evidence for nature of transformation pathways	
	¹⁴ C in organic matter fractions, methane, carbon dioxide	soil, soil gas, and water (as appropriate)	Provide evidence for depositional patterns or mixing in sediment layers	Provide evidence for transformation of anthropogenic hydrocarbons and transformation pathways	
5.6.3 Intrinsic Production of Methane in Anaerobic Lagoon Sediments, SOP 30.2	Methane production rate from anaerobic sediment segments	Headspace gas	Possible mixing in sediments due to methane evolution	Establish methanogenic conditions that promote transformation of PCBs	Measure rate of methane generation for evaluation of sediment cap alternative, and potential for long term transformations associated with methane in capped sediments
5.6.4 Intrinsic Transformation of PAHs and PCBs in Anaerobic Lagoon and Wetlands Sediments, SOP 30.3	Transformation rate of PCBs and PAHs	Anaerobic sediments		Measure intrinsic rate of transformation of PCBs and PAHs in sediments	Estimate transformation rates for sediment capping alternative
5.6.5 Constraints on Microbial Transformation of PAHs and PCBs in Lagoon Sediments, SOP 30.4	Transformation rates as controlled by selected electron acceptors	Sediments		Estimate rates of transformation of PAHs and PCBs associated with specific electron acceptors, and for better understanding of processes responsible for intrinsic transformation reactions	Assess potential utilization of electron acceptors to promote biotransformation of PAHs and PCBs in sediments

TABLE 5.3
DATA USE OBJECTIVES FOR
INTRINSIC SEDIMENT PROCESSES STUDY
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<u>Task/ SOP in Work Plan</u>	<u>Measurement</u>	<u>Media</u>	<u>Assessment of Migration Pathways and Toxicity</u>	<u>Evaluation of Intrinsic Remediation Processes</u>	<u>Evaluation of Issues Associated with Remedial Strategies</u>
5.6.6 Transformation of PCBs and PAHs in Vadose Zone Soil Plots, SOP 30.5	Transformation rate of PCBs and PAHs in wetland vadose zone soils, and influence of plants	Vadose zone soil		Measure intrinsic rate of transformation of PCBs and PAHs in soils, and influence of plant growth on transformation rates	Provide preliminary data on efficacy of phytoremediation of PAHs and PCBs present in dredged sediments
5.7 Processes in Disturbed Sediment Systems					
5.7.1 Leachate Characterization from Disturbed Seaplane Lagoon Sediments, SOP 26.5	Constituents present in simulated oxic leachate from sediments	Simulated leachate			Estimate metal concentrations in simulated leachate from dredged sediments exposed to rainwater.
5.7.2 Toxicity of Disturbed Sediments	Survival and developmental toxicity	Survival and developmental toxicity in disturbed sediments			Estimate survival and developmental toxicity associated with dredging of sediments

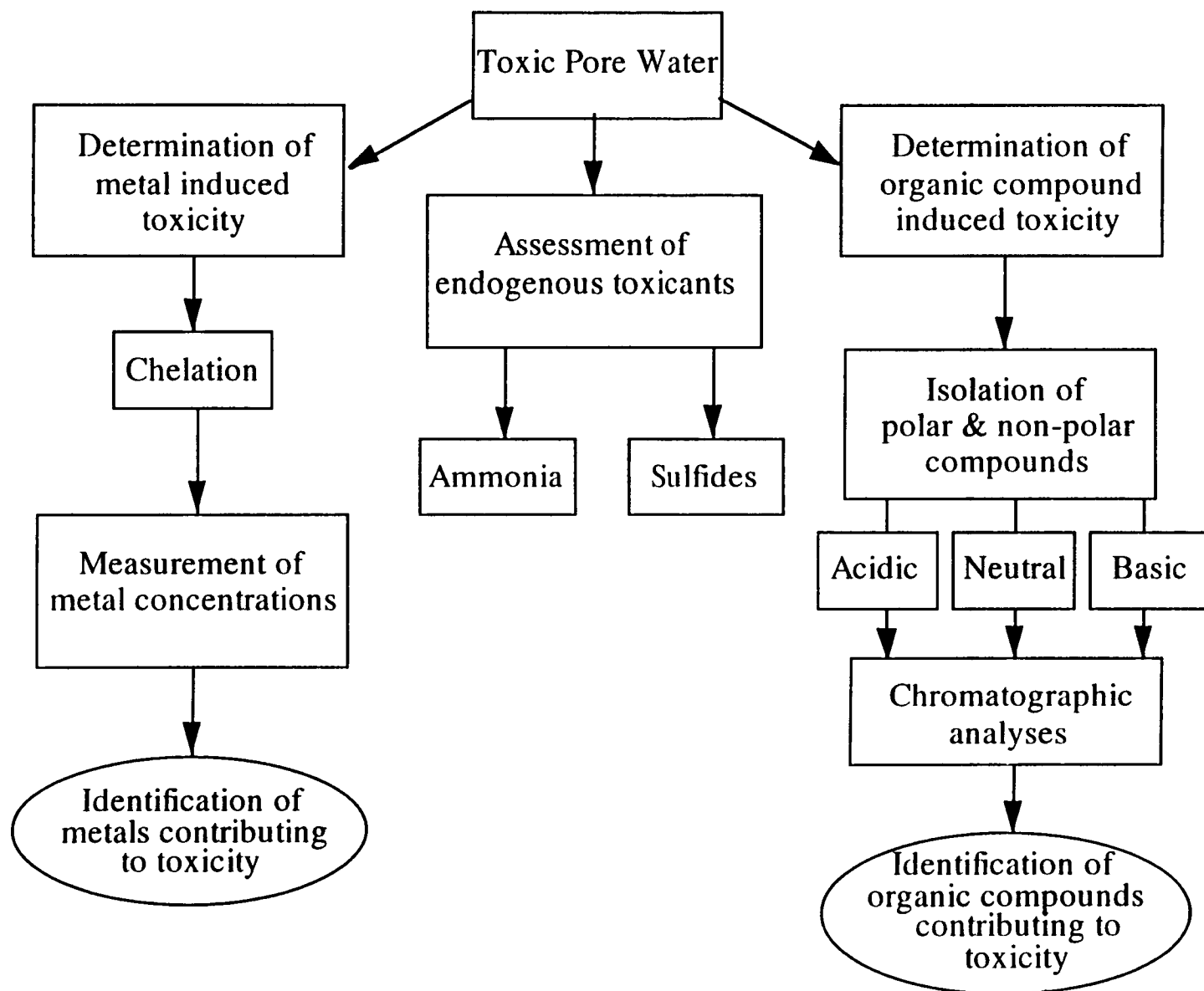


Figure 5.1 Approach for toxicity identification evaluations.

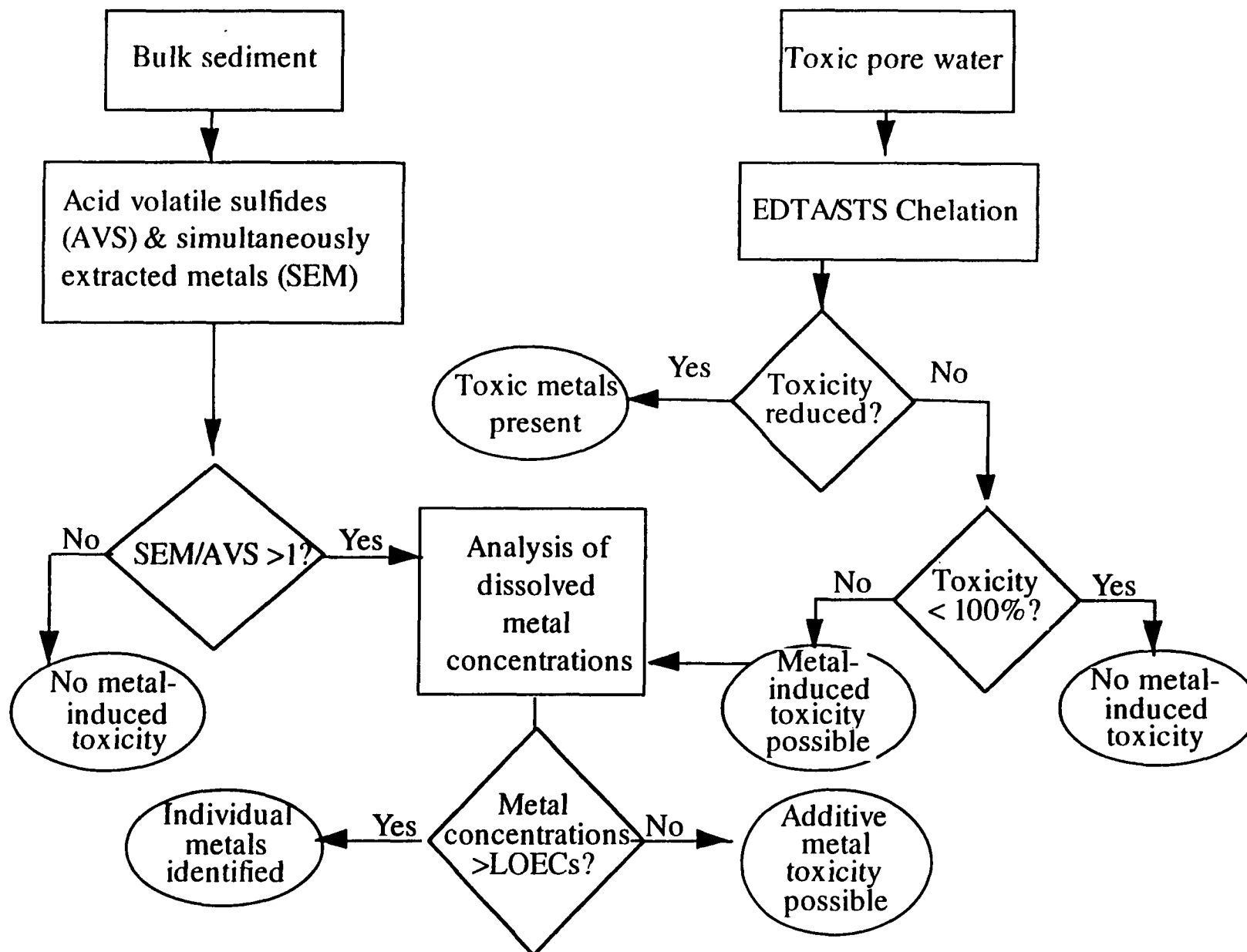


Figure 5-2. Pathway for the Assessment of Metal-Induced Toxicity

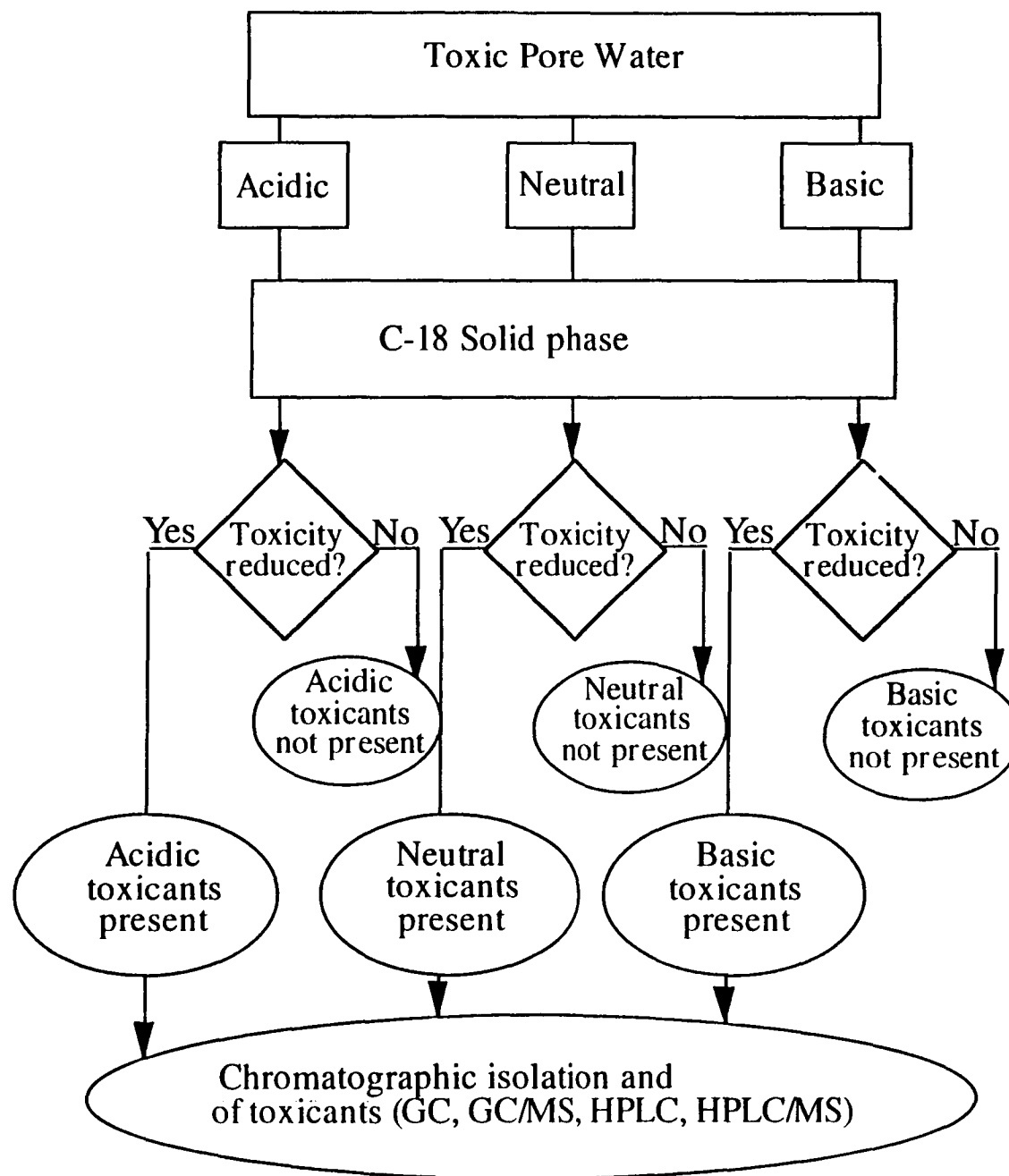


Figure 5-3 Pathway for Determination of Organic Chemical-Induced Toxicity

6.0 INTEGRATION

The complexity of sediment processes at NAS Alameda requires a multidisciplinary approach to characterize site conditions and adequately scope treatability studies. The previous sections describe the discipline-specific information on toxicity, bioaccumulation, chemistry, and environmental transport processes at the Seaplane Lagoon (Site 17) and the West Beach Landfill Wetland (Site 2) that will be obtained in the proposed BERF project. The sections below describe how this information will be integrated to meet the project objectives: (1) determine the toxicity and migration pathways for the chemicals of concern, (2) establish the time course of past and future intrinsic remediation, and (3) evaluate the impacts and issues associated with potential remedial strategies based on the collected data.

6.1 MIGRATION PATHWAYS

Marine and wetland sediments accumulate chemical releases and act as a reservoir to the environment. These chemicals are characterized as being of low solubility, highly sorbed and not volatile. The specific chemicals that have been the focus of the proposed studies are based on PRC investigations, and include PCBs, petroleum hydrocarbons including PAHs, and trace metals.

Diverse biological communities depend upon sediments for food, protection from predators, and as a semi-solid substrate suitable for sustaining rooted vegetation. For ecosystems, there are two issues that need to be addressed: (1) acute organism toxicity due to direct exposure to chemicals in sediments, and (2) chronic toxicity caused by long-term exposure to chemicals in sediment or through consumption of a contaminated prey. Bioaccumulation can result in chronic toxicity at the top of the food chain. Thus, ecosystem and human health impacts are initially controlled by the exposure to the contaminants in the biologically active region of the sediments, and then partitioning of contaminants from the sediments to biological organisms either through contact with the pore water or through sediment ingestion.

Toxicity tests coupled with toxicity identification evaluation (TIE) analyses will determine the specific chemicals causing acute and development toxicity from exposure to sediment pore waters. This information coupled with the Sediment/Water Interface Corer (SWIC) tests provide a direct determination of toxicity for organisms residing at the sediment-water interface. Additional data on bioaccumulation will be provided by the clam studies and digestive juice extracts following direct exposure to the sediments. It is expected that contaminants causing acute toxicity through pore water exposure will be different from contaminants that bioaccumulate. These results will assist the feasibility study in determining if special precautions or criteria are needed for specific contaminants when the sediments are exposed during a possible treatment option or when an isolation barrier or cap is designed for sediment containment.

The migration pathway for sediments at the Seaplane Lagoon and the Landfill Wetlands will be further analyzed through evaluation of sediment geochemistry. The sediment and pore water samples needed for bioaccumulation and toxicity tests are bulk samples that represent near-surface sediments. The integration of geochemical with toxicological studies will determine if toxicity was a consequence of sediment disturbance rather than chemical toxicity.

The traditional models that simulate chemical release from sediments are based on chemical transport by molecular diffusion modified by metal speciation reactions and organic chemical partitioning by sorption processes. Geochemical modeling assuming sulfide generation at depth and linear organic sorption will be used to estimate fluxes into and out of the sediments at the Seaplane Lagoon and at the wetlands site.

The assumption of the dominance of diffusion for chemical transport will be verified by field scale water flow studies at the lagoon and the wetland sites. Water flow in the Landfill Wetland will be quantified by direct measurement through an infiltration test (observations of water loss). Site-specific measurements of sediment properties and the depth of strata, and application of Darcy's law to site conditions will provide estimates of water flow in the Seaplane Lagoon. If flow is significant, then transport estimates can be improved over the conventional assumption that diffusion is the dominating mechanism.

6.2 TIME COURSE OF INTRINSIC REMEDIATION

The microbial, geochemical, and radioisotope analysis applied to the lagoon, wetlands, and the uplands sites will directly indicate the transformations that have occurred to date, and will provide an empirical basis for estimating future transformation rates.

For the Seaplane Lagoon the geochemical profile of the sediment redox chemistry provides the necessary data to compute advective or diffusive fluxes of electron acceptors that drive microbial transformations. These fluxes are expected to be at or near steady state rates over time scales of years assuming there has been no disturbance of the sediment profile. The carbon isotopic profile of the lagoon sediments provides additional information on the source of organic carbon that is driving the sediment redox chemistry.

Of particular interest for intrinsic remediation is the consumption of fuel hydrocarbons compared to natural organic matter because PAHs and PCBs are likely sequestered with the hydrocarbon phase at the high concentrations found within the lagoon sediments. The age-dated sediment profile and corresponding PCB congener changes discussed earlier provide the data to determine an overall PCB dechlorination rate that will be used to extrapolate the future time course of PCB dechlorination. Similarly, the analysis of tracers within the fuel hydrocarbons will permit determination of an overall oil degradation rate within the sediment profile. If the data available to us justify, the PAHs will be scaled with the hydrocarbon degradation. These calculations will arrive at overall rates for transformations of the organics. Given the expected loading of natural organic matter to the sediments and the high sulfate levels in the water column, the studies will show that the trace metals will either remain as sulfide solids or be transformed into them, and thus not be released.

For the wetlands, the time course of remediation cannot be estimated without first understanding the nature and to some limited extent, the spatial distribution of chemicals and site conditions. Geochemical, microbiological, and transport tools will be applied to the contaminants determined to be significant from ecotoxicology and bioaccumulation studies. Since a good age-related sediment profile is unlikely, PCB transformation rates will be assumed to be similar to those determined in the lagoon under similar redox conditions. Petroleum hydrocarbons and PAH degradation rates over time will be estimated from geochemical, microbial, and isotopic data, and extrapolating to the future under the current hydrodynamic conditions.

Thus, field and laboratory based measurements will provide the data needed to assess the rates at which intrinsic bioremediation will proceed under ambient conditions in the Seaplane Lagoon and the West Beach Landfill Wetland.

6.3 REMEDIAL STRATEGIES FOR ENHANCED REMEDIATION

As part of the characterization data collected as part of this effort, the consequences associated with a number of active remedial approaches can be evaluated, including disturbance-induced

dredging, exposure of deeper sediments, accelerating favorable biological transformations, and capping.

Any activity to remove the contaminated sediments from the Seaplane Lagoon will disturb the current sediment profile. Both hydraulic dredging and bucket dredges result in resuspended bottom sediments that originate in an anoxic environment and become mixed with oxygenated seawater. The studies in this program on sediment disturbance and leaching will determine the expected time course of metal and organic transformations and the changes, if any, in toxicity. There are options in sediment removal that might be able to minimize water column effects once these disturbances are determined depending upon which contaminant is the most significant.

Another consequence of sediment removal is the exposure of previously buried sediments that are not in chemical equilibrium with the overlying water column. Following removal of the overburden, the sediments will chemically and microbially re-equilibrate through the diffusion of oxygen and sulfate into the sediment layer. This exposed sediment will likely not be free of contaminants and our profiling experiments of chemical and toxic responses will determine the likely consequences of exposure for short and long time scales.

The field data collected during this effort, combined with a literature review on biochemical pathways for contaminant transformations, will suggest possibilities for enhancing the natural rate of biological remediation. For example, literature shows that anaerobic conditions that generate methane are found to be favorable for PCB dechlorination. Similarly, near surface oxidation of natural organic matter, fuel hydrocarbons, and some PCBs might be promoted by controlled injection of oxygen or other electron acceptors into the near surface sediments. The laboratory leachability study of the lagoon sediments will support the evaluation of upland treatment systems.

One option considered in most contaminated sediment situations is the capping of sediments in place or the placement of a cap over disposed sediments following dredging. Cap placement over weakly consolidated sediments composed of fine grained material has not been adequately considered in the engineering literature. This study's estimates of consolidation will include the expected consolidation of the sediments if capped in place and provide for an estimate of the time course of water flow induced by cap overburden. These data will permit analysis of the cap thickness needed to protect the overlying water column from long term releases.

7.0 QUALITY ASSURANCE PROJECT PLAN

This section presents the quality assurance/quality control procedures to be followed for the Intrinsic Sediment Processes Study. The project quality objectives are to provide field and laboratory data of sufficient quality to characterize the chemical and physical characteristics, toxicity, and biological transformation processes that are intrinsic to Site 17 (the Seaplane Lagoon) and Site 2 (the wetlands portion of the West Beach Landfill area).

Data quality objectives (DQOs) are critical to obtain data that are acceptable for their intended uses in ecological assessments or feasibility studies. As discussed above, the BERC studies primarily will rely on innovative methods to evaluate intrinsic processes in sediment systems. Such innovative methods have less experience from which to predict method performance, and this limitation includes the effects of matrices, outside interferences, and possibly other environmental variables (temperature, water quality, etc.). With regard to estimating rates of intrinsic processes, the rate of a process is a function of these natural (intrinsic) properties of the system and which are always site-specific. To provide data that meet the intent of the DQO process, the studies to be conducted by BERC will be subjected to a thorough review process that includes independent reviews by the Principal Investigator and the Contractor Quality Control Program Manager (CQCPM), a meeting of selected experts to critically review data and results, and a peer review of written reports conducted by the CQCPM. These quality control and quality assurance steps will then provide data of the highest quality for an informed use by the Navy and its contractors in the decision-making process at NAS Alameda.

7.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) for this project have been established in accordance with the procedures described in Section 8.3.3 of the Contractors Quality Control Program Plan (CQCPP). DQOs generally describe how the data will be collected to provide specific information; quality data are then numerical values that are sufficiently defined for a particular use. Data obtained using standard methods, such as published by regulatory agencies, are often evaluated based on past experience, collaborative testing, and continued proficiency testing by commercial laboratories. By comparison, innovative methods often have limited use and sometimes require specialized equipment, and require specialized expertise for evaluations. Data from innovative methods may have inherent uncertainties due to interferences, artifacts, and the effects of matrices associated with sample character (such as other chemicals present, difficulties with different sample properties). Criteria used in the DQO process address precision, accuracy, representativeness, completeness, and comparability of the data obtained.

A DQO development process developed by the U.S. EPA includes seven stages (see Table 7-1). The process draws from experience specifically based on obtaining data for regulatory use in risk assessment and remediation decision making. The process implicitly assumes that standardized methods are established such that experience has optimized the procedures for the analyses of interest, and the expected accuracy, precision, comparability, and representativeness of the measurements are defined. The process generally applies to all data collection activities, but for more innovative methods, the performance variables are less known or cannot be anticipated. For innovative methods, specialized expertise and judgment applied during the measurements is often required to determine the applicability, appropriateness and overall quality of the resulting data and information. The stages of the seven step process are identified on Table 7-1 with a description of how the DQOs are met for this project.

In setting the project DQOs, the studies in the proposed project are primarily intended to provide data for processes that are intrinsic to sediments at the sites, and use innovative techniques performed by the BERC team. The information from individual studies are not

intended to be used as sole criteria for decision making at NAS Alameda, but rather to be used with other data to develop an understanding of site conditions and processes. This understanding along with other data obtained using regulatory-approved methods will be used in the evaluation of risk and remedial alternatives. The reports prepared for each task in this study will discuss the DQO criteria as they pertain to the use of the data; this information may also be used in formulating future DQOs if the methods provide exceptional information that warrant further measurements that will be singularly critical in the decision making process.

7.2 QUALITY CONTROL CRITERIA

Project quality control criteria will include precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. Project specific limits for the methods are addressed in the Sampling and Analysis Plan. Each of the participating laboratories (from UCB, LLNL and LBNL) will be independently responsible for daily quality control and the quality control data will be independently reviewed by the project chemist.

7.2.1 Analytical Procedures

The analytical program for the Intrinsic Sediment Processes Study includes the innovative and recently developed measurements and tests described in Section 5 as well as standard analytical techniques. These measurements include:

- Acoustic imaging of sediment stratigraphy
- Geochemical measurements on pore water and sediment solids
- Toxicity studies
- Toxicity identification evaluations
- Bioaccumulation studies
- Measurements of sediment properties
- Water seepage flow in Seaplane Lagoon and Landfill Wetlands
- Transformation rate estimates based on sediment profile characteristics and simulated field measurements

The frequency of samples that will be characterized is summarized in Tables SAP-1 and SAP-2 of the SAP. All measurements will be performed by trained and experienced graduate students, scientists or technicians under the direction of a Co-Principal Investigator. All methods and results will be supervised and reviewed by the senior staff scientists and/or university professors at the respective laboratories.

The two sediment cores that will be examined by the project team at the site will be transported to the laboratory of the lead Principal Investigator as alternative sample sources to specific cores collected. Used PPE and equipment will be collected and appropriately disposed.

7.3 SAMPLE CUSTODY

Throughout field sampling activities, proper chain of custody procedures will be followed to demonstrate that samples were obtained from the locations stated and that they have reached the laboratory without alteration. Documentation of this will be accomplished using the Chain of Custody Record (COC). Chain of custody procedures will be implemented in accordance with SOP 1.1 and as described in Section 9.6 of the CQCPP. Copies of the completed COCs will be provided to the Project Chemist and maintained in the project files by serial number.

7.4 CALIBRATION AND MAINTENANCE OF MEASURING AND TEST EQUIPMENT

Anticipated laboratory and field measuring and test equipment (M&TE) that will require calibration is identified in the SOPs. Calibration and preventive maintenance procedures for this equipment, and any additional equipment that may be required for the project, are addressed in Section 15 of the CQCPP and in SQP 8.2, *Calibration and Maintenance of Measuring and Test Equipment*. The Contractor Project Manager will ensure that all equipment used in activities affecting quality will be calibrated according to these methods and procedures; laboratory directors, laboratory personnel, field superintendents, and field personnel will be responsible for implementing the procedures. Each item in the calibration program will be uniquely identified to assure its calibration status and identify the recalibration due date.

M&TE will be calibrated prior to use at the project site and at prescribed intervals thereafter, including at the completion of field work each day, in accordance with the manufacturer's recommendations. Calibrations will be performed by trained and qualified personnel. Records of calibration will be maintained by the Project Chemist for the items used on site. The laboratories will be required to implement and document an effective control program for M&TE used to perform the analyses. The calibration program will be audited by the Project Chemist to verify conformance to laboratory protocols and project requirements. Calibration of each piece of equipment will be recorded on the Test Equipment List and Calibration.

7.5 QUALITY CONTROL SAMPLES

QC sampling will be performed for this project to monitor and assess the quality of laboratory and field procedures. QC samples to be collected include appropriate field and laboratory blanks and laboratory replicate samples. Laboratory replicate samples will be characterized at the frequency specified in the SAP.

Laboratory QC samples for the conventional laboratory methods include method blanks, laboratory control samples, laboratory duplicate samples, and surrogate spikes. The frequency and method for analyses of these samples is addressed in Section 10 of the CQCPP.

7.6 SAMPLE COLLECTION, PRESERVATION AND HOLDING TIMES

Samples to be collected during the proposed studies include soil gas, soil, and groundwater samples. The numbers of samples to be analyzed and the required analyses are specified in the SAP. The required containers, preservation methods, and holding times for the Treatability Study assays are also summarized in the SAP.

7.7 SAMPLE COLLECTION LOGBOOK.

A sample collection logbook will be filled out for all samples collected. The sample collection logbook will include the following information:

- collection date and time
- project name
- unique sample number
- sample location and type
- container type and preservative
- compositing information
- depth of sample

- weather
- field observations
- problems encountered
- name of sample collector

Copies of the sample collection logbooks will be given to the Project Chemist to be filed in the project files.

7.8 DATA REDUCTION, VALIDATION, AND REPORTING

The procedures and data for each method will be documented in bound laboratory notebooks and Excel spreadsheets. Recorded data will be transferred to the computer within one month of collection and cross checked for accuracy. Data will be reported on the forms specified in each SOP included in Appendix A or other specific data management procedures for each assay as addressed in these SOPs.

In accordance with the requirements of Section 10.9.1 of the CQCPP, each laboratory will reduce the analytical data for standard analyses using procedures described in U.S. EPA document SW-846 (U.S. EPA, 1994c). The data will be verified by the laboratory and the Project Chemist according to the requirements of Section 10.9.2 of the CQCPP.

The laboratory will report all results in laboratory reports which will include the following at a minimum:

- a case narrative
- copies of COC forms
- analytical results for all samples included on the COC including dilutions and reanalyses and the laboratory detection limits used.
- analytical results for all required laboratory quality control samples

Independent of the laboratory review, the Project Chemist will perform data validation for ten percent of all analyses performed by standard analytical methods as specified in Section 10.10 of the CQCPP. The procedures to be used for data validation are contained in USEPA Contract Laboratory Program National Functional Guidelines Organic Data Review (U.S. EPA, 1994a) and in USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (U.S. EPA, 1994b). For parameters that are not included in these guidelines, the evaluation will be performed following HAZWRAP in DOE-HWP-65/RI.

7.9 QUALITY CONTROL MEETINGS

The Project Chemist will ensure that the following meetings are conducted in accordance with the requirements of Section 3.0 of the CQCPP:

- A coordination and mutual understanding meeting, held prior to the start up of the Treatability Study
- Quality control meetings, held quarterly following the start up of the Treatability Study. The Contractor Quality Control Program Manager will submit meeting notes to the U.S. Navy Remedial Project Manager within one week of each meeting

**TABLES
&
FIGURES**

TABLE 7-1**Summary of Data Quality Objectives for Intrinsic Sediment Processes Study**

Statement of Problem:	The Intrinsic Sediment Processes Study will evaluate the intrinsic processes that occur in sediment in the Seaplane Lagoon (Site 17), and in sediments and the vadose zone at the West Beach Landfill Wetlands (Site 2). The study is funded through Delivery Order 4 to Navy and UCB Partnership Agreement, issued by the Navy. The proposed study will utilize the resources from UCB, LBNL, and LLNL. The technical reports for this study will be reviewed by the Navy, regulatory agencies, and the Restoration Advisory Board.
Identify the Decision	The Intrinsic Sediment Processes study will provide information on topics related to decisions on remedial options for the Seaplane Lagoon, and on future management options due to conditions in the Landfill Wetlands. The results of the studies will be used with data from other investigations to evaluate the risk posed by current conditions to human and ecological health, and whether remedial alternatives will alleviate or exacerbate these risks in a short term (sediment disturbance) or long term context.
Identifying Inputs	<p>The Intrinsic Sediment Processes Study includes field studies and laboratory studies at Site 2 and 17 that address the topics:</p> <ul style="list-style-type: none">• The chemical composition of pore water and speciation of sediments• The survival and developmental toxicity of pore water and at the sediment water interface• Bioaccumulation of selected organic chemicals from sediments• Sediment depositional history, and water transport at sites• Transformation reaction in sediments and soils by product analyses isotope ratios, and field studies• The leachate composition from disturbed sediments and the toxicity of disturbed sediments <p>The studies will be accomplished using innovative methods as well as the specialized equipment and expertise available from UCB, LBNL, and LLNL. The methods and equipment are documents in the Work Plan and in the Sampling and Analysis Plan (SAP). Action levels for specific chemicals have not been set for these sites, and the results from the proposed can be used in evaluating risks from existing conditions as well as from future conditions. (See Table 5-3).</p>
Define Boundaries	The proposed studies have been planned based on incomplete data that describes the extent of chemicals present, and very little data are available on the physical characteristics of the lagoon and Landfill Wetlands (seawalls and levees). Several studies (notably acoustic imaging and sediment profiles) will also provide a better definition of the sediment depth and depth of chemicals present.

TABLE 7-1
(Continued)

Develop Decision Rule	If study results demonstrate the intrinsic processes control the availability of chemicals from sediments at the sites and that the potential toxicity and bioavailability associated with Navy chemicals is low, then a "no action" option may be included in feasibility studies for these sites. The studies will also evaluate the depth of selected chemical constituents using innovative methods. Alternatively, if the studies show that short term toxicity and bioavailability is increased or unchanged, then the "no action" decision also must be considered in the feasibility studies for these sites.
Specify Limits on Decision Error	The Work Plan and SAP (including SOPs) discuss the reporting limits and the basis for the methods that determine the accuracy of the measurements. The results of the several studies will be used in making pivotal decisions, and therefore the consequences of false positive or false negative data are minimized for this study, and for decision making.
Optimize the Design	The design of each study has been optimized based on available site data and the method to be conducted. For most methods, sampling and methods application are focused on evaluating intrinsic processes as a function of depth, and not for a lateral comparison of data. As stated in the text, given the innovative nature of many of the methods, the expertise of the Co-Principal Investigators will also be required to redefine quality performance and potential data uses depending on the outcome of the pressed studies.

8.0 REPORTING

The proposed Treatability Study program consists of a number of individual studies to assess the chemical characteristics, toxicity and behavior of chemicals in sediments at the two sites. Progress and adherence to schedules will be reported in the Monthly Contract Performance Report submitted to the Navy.

Because the separate studies will likely be completed on different schedules, complete technical reports for each study will be prepared within 3 months after the laboratory and data analysis phase of the study is complete. Technical reports for the individual studies will be reviewed for adherence to the Work Plan and format by the Contractor Quality Control Program Manager. With approval of the Program Director, the technical report will be sent to the Navy for informational purposes. With the Navy's concurrence, the technical report will be sent for peer review. Based on peer review, the technical report will be revised and submitted to the Navy as a Draft Technical Report. Following Navy review and revisions by BERC, the technical reports will be retained and combined in a Final Report for the Delivery Order.

Six technical reports will be submitted, corresponding to the task organization depicted in Figure 3-1 and 3-2. Results of the disturbance studies will be reported in the respective sections on chemical characterization and toxicity studies. These reports include:

- Physical Characterization of Sediment
- Chemical Characterization of Pore Water and Sediment
- Pore Water and Sediment Toxicity
- Bioavailability Evaluation
- Transport Processes Assessment
- Intrinsic Transformation Processes

9.0 PROJECT MANAGEMENT

9.1 SCHEDULE

The implementation schedule for the proposed studies are presented in Figures 9-1 and 9-2. Mobilization for the initial Seaplane Lagoon sampling phase of the project will require approximately one month following notice to proceed from the Navy. As indicated in the schedule, the Acoustic Imaging task will be conducted first, and requires no sampling efforts. BERC has requested that this effort be allowed to proceed ahead of the final approval of the complete project schedule and tasks, as the information from the acoustic imaging is critical for both BERC's activities and for PRC's investigations. The plan for the initial sampling effort is to collect the deeper boring samples using a subcontractor with deeper coring experience to get a number of tasks underway as soon as possible. Laboratory studies using sediment samples will begin immediately after sample collection. The rest of the sampling efforts in the Seaplane Lagoon (toxicity and TIE) can be completed using facilities and personnel from LBNL and LLNL with appropriate experience for surface sediment sampling.

9.2 ORGANIZATION AND RESPONSIBILITIES

Management and supervision of field sampling activities at the Seaplane Lagoon and the West Beach Landfill Wetlands will be performed by ATG, BERC's lead subcontractor; UCB's Health and Safety officer has prime authority over all persons onsite during sampling, acoustic imaging, and other field activities. All laboratory studies will be conducted within the facilities of the respective participating groups (LBL, LLNL, UCB), and the health and safety activities, administration, general training, equipment maintenance, and other management functions will be performed under the authority of the respective organizations.

Dr. James R. Hunt of UCB, Department of Civil and Environmental Engineering, will be the Principal Investigator for project. Dr. Hunt will be responsible for technical oversight for the project, and will be assisted by Co-Principal Investigators from UCB, LBNL, and LLNL. The list of the Co-Principal Investigators follows. BERC subcontractor staff provide assistance for assuring compliance with the overall Program purpose and objectives as described in this Workplan and the Contractor Quality Control Program Plan, dated May 24, 1996. Arvind Acharya, R.G., of ATG, Inc. is Contractor Project Manager, William Mabey, Ph.D., of ITSI, is the Contractor Quality Control Program Manager, and Peter Yimbo, Ph.D., of the Ellington Group, is Project Chemist.

<u>Task</u>	<u>Investigator Organization</u>	<u>Laboratory Support</u>
Acoustic Imaging	Dr. Patrick Williams, UCB	None
Chemical Characterization of Pore Water and Sediment Toxicity	Dr. Susan Carroll, LLNL	LLNL Geochemistry Laboratory
Toxicity Identification Evaluation	Dr. John Knezovich, LLNL	LLNL Environmental Chemistry Laboratory
Bioaccumulation	Dr. Donald Weston, UCB	Skidaway Institute of Oceanography
Transport/Lead-210 Dating	Dr. James Hunt, UCB	Dr. Brad Esser, LLNL Isotope Division
Transport/Physical Properties	Dr. Nicholas Sitar, UCB	UCB Graduate Geotechnical Laboratory
Transformation/PAH and PCB Products	Dr. James Hunt, UCB	Scott Mountford, LBNL Environmental Measurement Laboratory
Isotope Measurements	Dr. Mark Conrad	LBNL Isotope Sciences Division Laboratory
Methane Production in Lagoon Sediments	Dr. Mary Firestone, UCB	UCB Soil Science Laboratory
Transformation/PCB and PAH Studies	Dr. Mary Firestone, UCB	Scott Mountford LBNL Environmental Measurement Laboratory

**TABLES
&
FIGURES**

Figure 9-1
Task Schedule

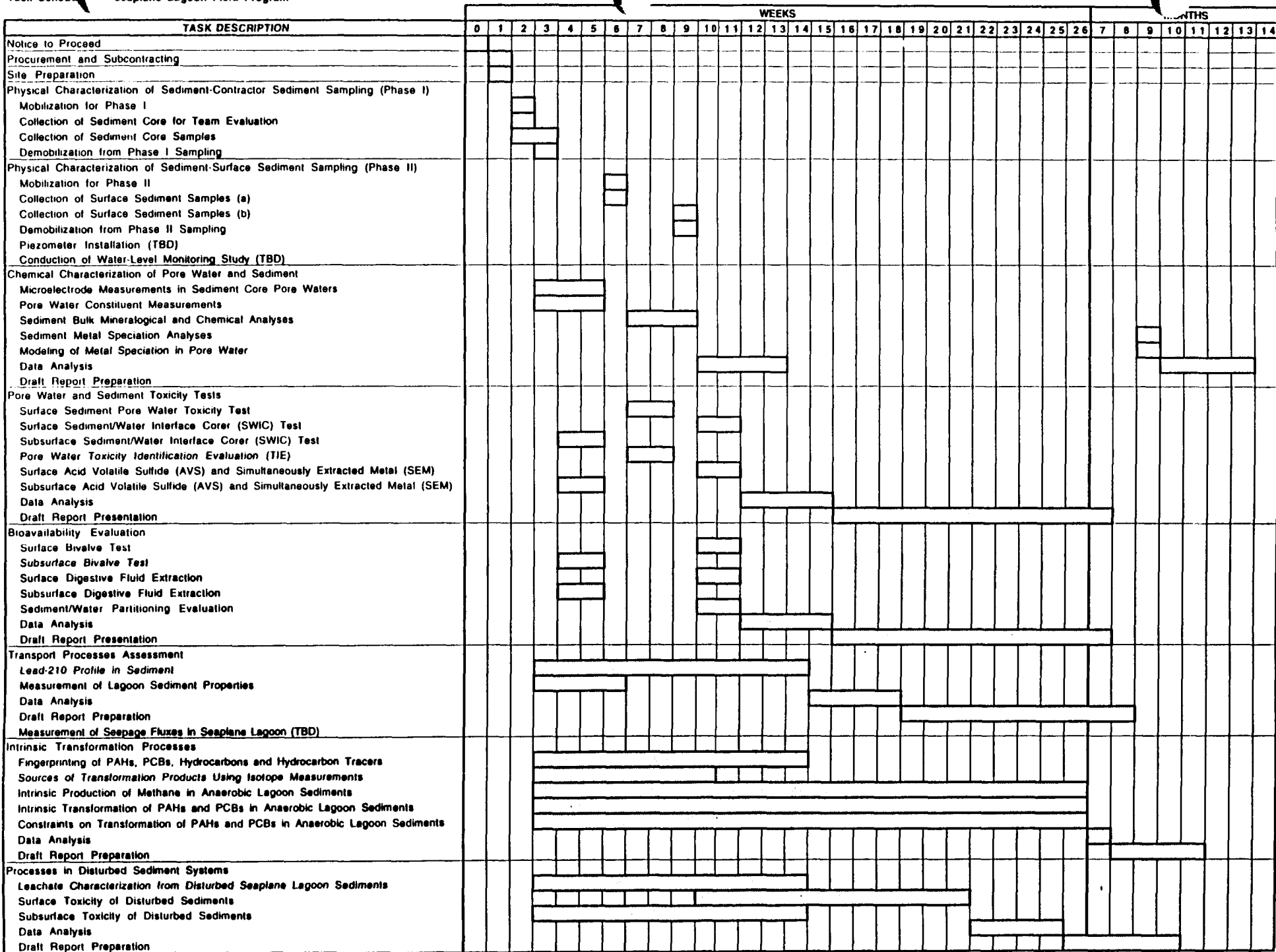
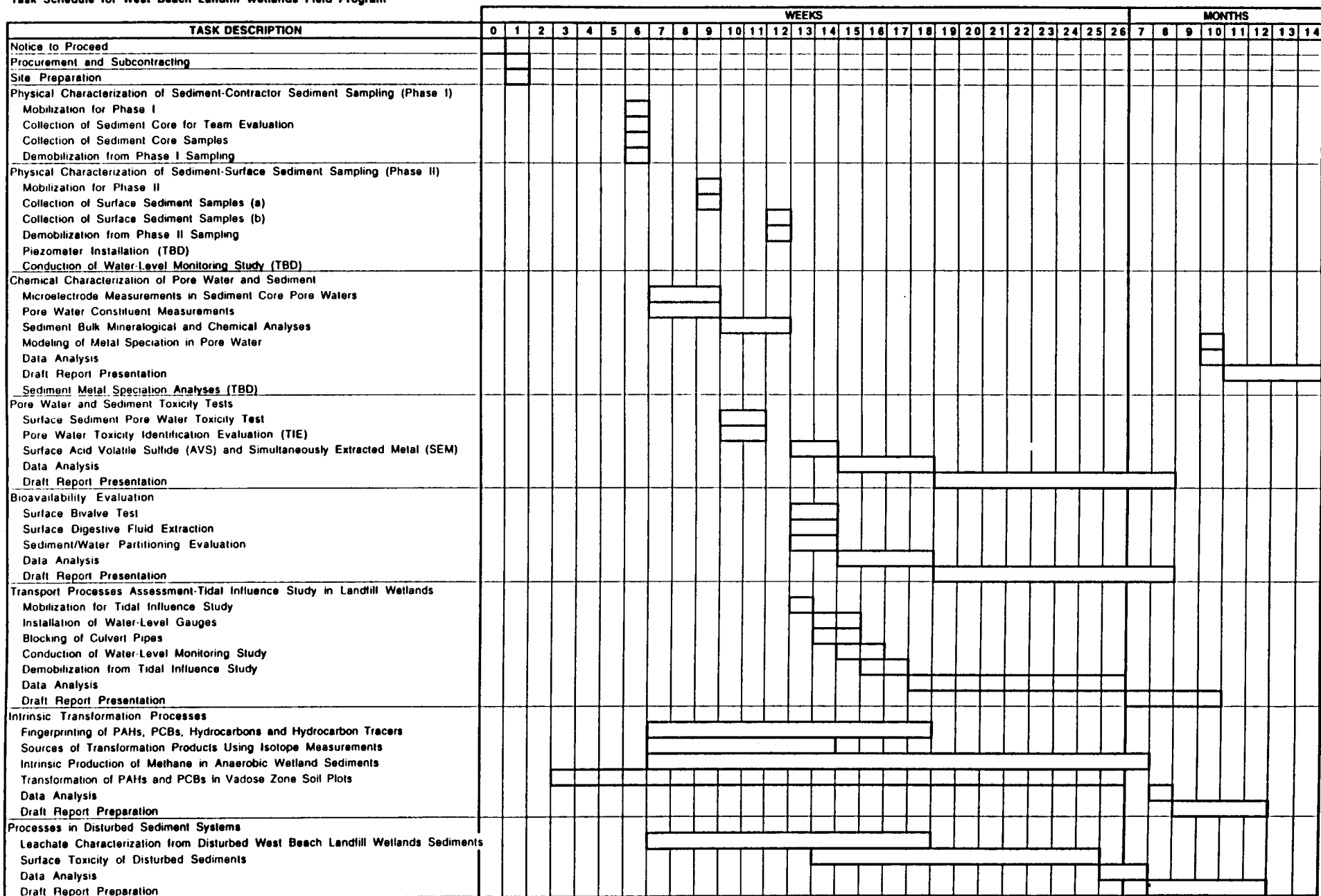


Figure 9-2
Task Schedule for West Beach Landfill Wetlands Field Program



APPENDIX A

RESUMES

SUSAN LESLIE ANDERSON, Ph.D.

Over the past decade, Dr. Anderson has directed investigations in aquatic ecotoxicology. Of particular interest are projects applying genetic and reproductive toxicology to evaluations of ecological health. This research focus is complemented by extensive experience in ecological risk assessment and its application in environmental policy.

EDUCATION

Ph. D. Ecology, University of California, Davis, 1978-1984

B.A. (Honors) Occidental College, Los Angeles, California, 1972-1973, 1974-1976

Dartmouth College, Hanover, New Hampshire, 1973-1974

PROFESSIONAL HISTORY

Lawrence Berkeley Laboratory, Energy and Environment Division, Berkeley, CA, Staff Scientist 1990-1995, Ecological Research Group Leader 1995--.

California Water Quality Control Board, San Francisco Bay Region, Oakland, CA, Environmental Specialist March 1986 to May 1990.

Lawrence Livermore National Laboratory, Environmental Sciences Division, Livermore, CA, Postdoctoral Researcher July 1983 - March 1986, Consultant March 1986 to March 1989.

U.S. National Marine Fisheries Service, Tiburon, CA, Consultant June - November 1982.

Lockheed Center for Marine Research, Diablo Canyon Nuclear Power Plant, Avila Beach, CA, Staff Scientist June 1976 - August 1978.

KEY ACCOMPLISHMENTS

GENETIC AND REPRODUCTIVE ECOTOXICOLOGY: Established relationships between genotoxic and reproductive damage using aquatic and terrestrial organisms and including multigeneration impacts. Evaluated genotoxic effects associated with increasing UV-B in Antarctica and Alaska.

ECOLOGICAL RISK ASSESSMENT: Developed a hazard assessment and risk management scheme to evaluate and control risk to aquatic life from ocean disposal of low-level radioactive wastes and conducted research on the genotoxic and reproductive effects of ionizing radiation.

AQUATIC TOXICOLOGY: Established first comprehensive toxicity biomonitoring program in San Francisco Bay to assess impacts of waste discharge practices on the health of the estuarine ecosystem. Evaluated effects of pollutants on wetland ecosystems of San Francisco Bay, resulting in successful redesigning of a treatment marsh. Validated new techniques for sediment toxicity assessment.

ACADEMIC AWARDS

Pew Scholar in Conservation and the Environment, 1992 (among first 30 worldwide)

Lawrence Berkeley Laboratory Outstanding Performance Award, 1993

Lerner-Gray Fund for Marine Research, Doctoral Research Award, American Museum of Natural History, New York, 1982

Five University of California Davis graduate research awards, 1979-1982

Occidental College International Fellowship--undergraduate award for research in France, 1975 (received medal from French oceanographic agency, CNEXO).

PROFESSIONAL AFFILIATIONS

Society of Environmental Toxicology and Chemistry

Environmental Mutagen Society

Genetic and Environmental Toxicology Association

COMMITTEE MEMBERSHIPS

Member, Executive Committee of the University of California Toxic Substances Research and Teaching Program (1990-1995)

Chair, Napa Conference on Genetic and Molecular Ecotoxicology (1993)

Member, Executive Committee and Faculty Affiliate, Energy and Resources Group, University of California, Berkeley (1993-present)

Chair, Technical Advisory Committee, USEPA San Francisco Estuary Project (1988-90)

Member, State of California Marine Bioassay Protocol Review Committee (1992-present)

Member, GESAMP/UNEP Working Group No. 33 on Biomarkers and Marine Pollution (1994)

Member, SETAC New Initiatives Committee (1993-94)

PUBLICATIONS

Anderson, S.L. 1977. Artisanal methods in French oysterculture: a regional comparison. *Proceedings of the World Mariculture Society* 8:373-386.

Hines, A., S. Anderson, and M. Brisbin. 1980. Heat tolerance in the black abalone, *Haliotis cracherodii* Leach, 1814: effects of temperature fluctuation and acclimation. *Veliger* 23(2):113-118.

DeVlaming, V., D. Baltz, S. Anderson, R. Ritzgerald, G. Delahunty and M. Barkley. 1983. Aspects of embryo nutrition and excretion among viviparous embiotocid teleosts: potential endocrine involvements. *Comparative Biochemistry and Physiology* 76:189-198.

Anderson, S.L. 1984. Molt and Reproduction of the Ridgeback Prawn, *Sicyonia ingentis* (Penaeidae). Ph.D. Dissertation, University of California Davis.

Anderson, S.L., W.H. Clark, Jr., and E.S. Chang. 1984. Timing of postvitellogenic ovarian changes in the ridgeback prawn, *Sicyonia ingentis* (Penaeidae) determined by ovarian biopsy. *Aquaculture* 42:257-271.

Anderson, S.L., W.H. Clark, Jr., and E.S. Chang. 1985. Multiple spawning and molt synchrony in a free-spawning shrimp (*Sicyonia ingentis*: Sicyoniidae). *Biological Bulletin* 168:377-394.

Anderson, S.L., L. Botsford, and W.H. Clark, Jr. 1985. Size distributions and sex ratios of ridgeback prawn (*Sicyonia ingentis*) in the Santa Barbara Channel, 1979-1981. *California Cooperative Fisheries Investigation Reports* 26:169-174.

Anderson, S. and F. Harrison. 1986. Effects of Radiation on Aquatic Organisms and Radiobiological Methodologies for Effects Assessments. U.S. EPA, Washington, D.C. (EPA 520/1-85-016).

Krauter, P., S. Anderson, and F. Harrison. 1987. Radiation-induced micronuclei in peripheral blood erythrocytes of *Rana catesbeiana*: an aquatic animal model for *in vivo* genotoxicity studies. *Environmental Mutagenesis* 10:285-296.

Anderson, S., F. Harrison, G. Chan and D.H. Moore II. 1988. Chromosomal aberrations, reduced fecundity and lifespan in irradiated polychaete worms. U.S. EPA, Washington, D.C. (EPA Technical Report 520/1-87-007).

Harrison, F.L. and S.L. Anderson. 1989. Reproductive success as an indicator of genotoxicity in the polychaete worm, *Neanthes arenaceodentata*. *Marine Environmental Research*. 28:313-316.

Harrison, F. and S. Anderson. 1989. Chapter 30. Effects of radiation on reproductive success of the polychaete worm *Neanthes arenaceodentata*. IN: Interim Oceanic Description of the Northeast Atlantic Site for the Disposal of Low-Level Radioactive Wastes (IOD-3). Nuclear Energy Agency (NEA), Paris, France.

Anderson, S., F. Harrison, G. Chan and D.H. Moore. 1990. Comparison of whole animal and cellular bioassays in the prediction of radiation effects on marine organisms. *Archives of Environmental Contamination and Toxicology*. 19:164-174.

Anderson, S., G. Wild, D. Littlejohn and J. Harte. Multigeneration exposures to genotoxic agents cause sterility in the nematode *Caenorhabditis elegans*. For submittal to *Nature Letters*.

Anderson, S. and G. Wild. An assay for detecting sublethal effects of contaminants in sediment pore water using the nematode *Caenorhabditis elegans*. For submittal to *Environmental Toxicology and Chemistry*.

Gray, E. and S. Anderson. Effects of of mitomycin-C on female germ cells of the Japanese medaka *Oryzias latipes*. For submittal to *Ecotoxicology*.

D. Karentz, I. Bosch, J. Hoffman and S. Anderson. Responses of Antarctic sea urchins to laboratory and solar ultraviolet-B exposures. For submittal to *Marine Biology*.

Anderson, S., J. Hoffman and M. Wilson. Genotoxic and developmental responses to arsenic exposure in three species. For submittal to *Bulletin of Environmental Toxicology and Chemistry*.

OTHER PUBLICATIONS AND REPORTS

Dr. Anderson has published numerous UC series and national laboratory reports; these are only cited below if they contain substantial information that was not published, in press, or submitted elsewhere.

Anderson, S. and S. Hansen. 1982. Determination of West Coast Groundfish Primary marketing channels. National Marine Fisheries Service, NOAA, Contract 82-ABA-2087, La Jolla, CA.

Anderson, S. and F. Harrison. 1986. Regeneration used in an improved genotoxicity assay for adult polychaete worms (*Neanthes arenaceodentata*). UCRL no. 95749.

Ritchie, S., S. Anderson, D. Tempelis, M. Carlin and K. Garrison. 1986. Water quality control plan for the San Francisco Bay Basin. California State Water Resources Control Board, Sacramento, CA.

Anderson, S., W. Pease, M. Carlin and T. Mumley. 1987. San Francisco Bay Regional Water Quality Control Board Effluent Toxicity Characterization Program. Guidelines of the San Francisco Bay Regional Water Quality Control Board. Oakland, CA.

Pease, W., K. Taylor, and S. Anderson. 1989. Toxic Substances of Concern and Potential Water Quality Objectives for the Protection of Aquatic Life and Human Health. Technical Report No. 1, Planning Division San Francisco Bay Regional Water Quality Control Board Oakland CA.

Anderson, S., E. Hoffmann, D. Steward and J. Harte. 1990. Ambient toxicity characterization of San Francisco Bay and adjacent wetland ecosystems. LBL Report No. 29579.

Anderson, S.L. 1992. Monitoring genetic damage to ecosystems from hazardous waste. Proceedings of the Pacific Basin Conference on Hazardous Waste. Bangkok, Thailand, April 6-10, 1992.

E. Hoffman, J. Knezovich, and S. Anderson. 1995. Determinants of sediment toxicity in San Francisco Bay. LBL Report No. 36592.

Anderson, S.L., G. Wild, N. Kado, R. Katznelson, W. Sadinski, J. Hoffman and W. Jewell. Genotoxic and developmental responses in three species exposed to contaminated sediment pore water. LBL report No. 33751. (draft under revision)

GESAMP/UNEP Working Group No. 33. 1995. Biomarkers and marine pollution. (one of several working group members)

Dr. Anderson has published 24 abstracts. Her work has been reviewed in the scientific and popular press in sources as diverse as Science magazine, the San Francisco Chronicle and local television.

CURRICULUM VITAE

SUSAN A. CARROLL

Date of Birth: February 7, 1961

Earth Sciences Department
Lawrence Livermore National Laboratory
Livermore, CA 94551

EDUCATION

- 1983-1989 **Ph.D., Geochemistry, Northwestern University** Evanston, IL
Thesis: The dissolution behavior of corundum (25°C),
kaolinite (25, 60, 80°C) and andalusite (25°C): A surface complex
reaction model for the dissolution of aluminosilicate minerals
in diagenetic and weathering environs.
- 1979-1983 **B.S., Geology, University of Kansas** Lawrence, KS

PROFESSIONAL EXPERIENCE

- 1992-present **Lawrence Livermore National Laboratory** Livermore, CA
Environmental Geochemist: Experimental studies of rock-water
reactions.
- 1990-1992 **University of Missouri-Columbia** Columbia, MO
Assistant Professor: Developed undergraduate and graduate
environmental / low temperature aqueous geochemistry programs.
Research included investigation of rock-water interactions in the silicate and
carbonate systems at near earth surface pressures and temperatures.
- 1990 **National Center of Scientific Research (CNRS)** Orsay, FRANCE
Research Scientist: Mobility of nuclear waste within the geosphere:
The application of high energy ion beam techniques to investigate trace
metal interactions at the calcite-solution interface.
- 1989-1990 **Royal Institute of Technology** Stockholm, SWEDEN
Research Scientist: Mobility of nuclear waste within the geosphere:
The sorption of trace metals to calcite in aqueous solutions.
- Summer 1985 **Exxon Production Research Company** Houston, TX
Research Assistant: Characterization of the chemical and physical
properties of clay minerals in "shaly sands".
- Summer 1984 **The Swiss Federal Institute for Dübendorf, SWITZERLAND**
Water Resources and Water Pollution Control (EAWAG)
Research Assistant: Kaolinite dissolution kinetic studies at 25°C.

PROFESSIONAL OFFICE

- 1994-1997 **Geochemical Division of the American Chemical Society,**
Secretary

PUBLICATIONS*

- Oday, P. A., Carroll, S. A., Waychunas, G. A., Phillips, B. (1995). XAS of trace element coordination in natural sediments at ambient and cryogenic temperatures. *Physica B* 208/209, 309-310.
- Brady, P. V. and Carroll, S. A., (1994). Direct effects of CO₂ and temperature on silicate weathering: Possible implications for climate control. *Geochimica et Cosmochimica Acta* 58, 1853-1856.
- Carroll, S. A., (1993). Precipitation of Nd-Ca carbonate solid solution at 25°C. *Geochimica et Cosmochimica Acta* 57, 3383-3393.
- Carroll, S. A., Bruno, J., Petit, J. C., and Dran, J. C., (1992). Interactions of U(VI), Nd(III), and Th(IV) at the calcite-solution Interface. *Radiochimica Acta* 58/59, 245-252.
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- Carroll, S. A. and Walther, J. V., (1990). Kaolinite dissolution at 25, 60, and 80°C. *American Journal of Science* 290, 797-810.
- Carroll-Webb, S. A. and Walther, J. V., (1988) A surface complex reaction model of the pH dependence of corundum and kaolinite dissolution rates. *Geochimica et Cosmochimica Acta*, 52, 2609-2624.
- Webb, Susan Carroll and Wood, B. J., (1986). Spinel-pyroxene-garnet relationships and their dependence on Cr/Al ratio. *Contribution to Mineralogy and Petrology* 92, 471-480

SYMPOSIUM PROCEEDINGS AND REPORTS

- Carroll S., Copenhaver S., and Alai M. (1995) Experimental investigation of hydrous pyrolysis of diesel fuel: Potential impact on the proposed high-level radioactive waste repository, Yucca Mountain, Nevada. (in revision LLNL-UCRL.)
- O'Day P. A., Carroll S. A., Waychunas G. A., and Phillips B. (1995) XAS of trace element coordination in natural sediments at ambient and cryogenic temperatures. (in press) 21ST. Annual Users Conference, Stanford Linear Accelerator Center.
- Bates, J. K., Bourcier, W. L., Bradley, C. R., Brown, N. R., Buck, E. C., Carroll, S. A., Cunnane, J. C., Dietz N L., DiSanto, T., Ebert, W. L., Emery, J. W., Feng, X., Gerding, T. J., Gong, M., Hafenrichter, L. D., Hoh, J. C., Mazer, J. J., Morgan, L. E., Newton, L., Phillips, B. L., Pletcher, R., and Wronkiewicz, D. Z. (1994) ANL technical support program for DOE environmental restoration and waste management, *Annual Report October 1992-September 1993* ANL-94/19.
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- Carroll, S. A., Bourcier, W. L., and Phillips, B. L. (1994). Surface chemistry and durability of borosilicate glass. *Mat. Res. Soc. Symp.* 333, 533-540.
- Jackson, K. J. and Carroll, S. A. (1994) Experimental investigation of hydrous pyrolysis of diesel fuel and the effect of pyrolysis products on performance of the candidate nuclear waste repository at Yucca Mountain. *Mat. Res. Soc. Symp.* 333, 841-847.
- Stout, D. L. and Carroll, S. A. (1993). A Literature review of actinide-carbonate mineral interactions. *SAND92-7328*.
- Carroll, S. A. (1992). Mechanisms controlling NdOHCO₃-CaCO₃ solid solution formation. *Proceedings of the 7th International Symposium: Water-Rock Interaction*, Miles (ed.) Balkema, Rotterdam, p.89-92.
- Bruno, J., Carroll, S., Sandino, A., Charlet, L., Karthein, R., and Wersin, P. (1989). Adsorption, precipitation and coprecipitation of trace metals on carbonate minerals at low temperatures. *Proceedings of the 6th International Symposium: Water-Rock Interaction*, Miles (ed.) Balkema, Rotterdam, p.121-124.

* Please note that I have published under the names Carroll, Carroll-Webb, and Webb.

ABSTRACTS

- Carroll S. A., Alai M., Mroczek E. K., Ebert M. (1995) Amorphous silica precipitation rates: Comparison of laboratory and field determinations. *GSA Abstracts with Programs*.
- O'Day P., Carroll S. Waychunas G. (1995) Bonding and coordination of trace metals in acid-mine sediments using synchrotron x-ray Absorption Spectroscopy. *GSA Abstracts with Programs*.
- Carroll S., O'Day P., Waychunas G., and Phillips B., (1995) EXAFS of heavy metal coordination in acid mine drainage. *American Chemical Society* 209, GEOC-008.
- Carroll S., Phillips B., O'Day P., Waychunas G., and Piechowski M. (1994) Environmental applications of EXAFS: Zinc structure in acid mine drainage sediments. *GSA Abstracts with Programs*.
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- Piechowski, M. and Carroll, S. A. (1994). A field study of the mobility of Cd, Pb, and Zn in the Tri-State Mining district. *American Chemical Society* 207, ENVR 206.
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- Carroll, S. A. (1993). Characterization of the calcite-solution interface. *American Chemical Society* 205, GEOC 134.
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- Carroll, S. A., Bourcier, B. L., and Phillips, B. L. (1993). Surface chemistry and durability of borosilicate glasses. *Materials Research Society*, p.534.
- Jackson, K. J. and Carroll, S. A. (1993) Experimental investigation of hydrous pyrolysis of diesel fuel and the effect of pyrolysis products on performance of the candidate nuclear waste repository at Yucca Mountain. *Materials Research Society*, p. 544.
- Carroll, S. A., Bruno, J., Petit, J. C., and Dran, J. C. (1991). Interactions of U(VI), Nd(III), and Th(IV) at the calcite-solution Interface. *Third International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere*, p. 144-145.
- Bruno, J. and Carroll, S. A. (1989). Adsorption and coprecipitation in the U(VI)-calcite system. *Second International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere*, p.78.
- Webb, Susan Carroll and Walther, J. V. (1988). Dissolution mechanisms of andalusite at 25°C. *GSA Abstracts with Programs* 20, A41.
- Webb, Susan Carroll and Walther, J. V. (1988). Temperature dependence of kaolinite dissolution. *GSA Abstracts with Programs* 20, A41.
- Webb, Susan Carroll and Walther, John. V. (1987). Surface complexation reactions and the pH dependence of corundum dissolution. *International Congress of Geochemistry and Cosmochemistry in Chemical Geology* 70, p. 83.
- Webb, Susan Carroll and Walther, John V. (1986). A surface complexation model for the dependence of aluminosilicate dissolution rates. *GSA Abstracts with Programs* 18, 784.
- Webb, Susan Carroll and Wood, B. J. (1984). Chromium-aluminum partitioning between clinopyroxene and spinel. *Amer. Geophys. Union Trans. (EOS)* 65, 293.

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EDUCATION

Ph.D. in Geology (Harvard University, March 1990)

Thesis: The relation of propylitic alteration and O^{18} -depletion patterns to Ag/Au vein deposits in the Tayoltita mining district of Durango, Mexico.

A.M. in Geology (Dartmouth College, June 1982)

Thesis: Variations within the layering of the Skaergaard intrusion, East Greenland.

B.A. in Geology (Pomona College, May 1979)

Thesis: The petrology of a portion of the San Dimas Experimental Forest, San Gabriel Mountains, southern California.

PROFESSIONAL EXPERIENCE

Geological Scientist (Lawrence Berkeley National Laboratory; 5/95-present): Monitoring subsurface bacterial activity with stable isotopes, paleoclimatic patterns in California and stable isotope systematics of clay minerals.

Geologist Postdoctoral Fellow (Lawrence Berkeley National Laboratory; 5/92- 5/95): Stable isotope evidence for subsurface bacterial activity, groundwater hydrology and water-rock interaction in geothermal systems.

Research Associate (Dartmouth College; 10/90-5/92): Research on fluid-rock interaction in a variety of geologic environments.

Consulting geologist (Meridian Gold Company; 4/88-12/88, 3/90-5/90): Evaluation of gold property in the Mother Lode of California.

Teaching Fellow (Harvard University; 1984-1987): Introductory mineralogy and summer field camp.

Exploration Geologist (Anaconda Minerals Company; 6/80-10/80, 3/81-7/81, 6/82-8/83): Evaluation of properties in the United States and Mexico.

Teaching Fellow (Dartmouth College; 1979-1982): Optical mineralogy, igneous and metamorphic petrology, structural geology and field methods.

Summer Geologist (Noranda Exploration, Inc.; 5/79-8/79): Reconnaissance mapping of volcanic rocks in Arizona to evaluate mineral potential.

Professional Affiliations: Geological Society of America, Mineralogic Society of America, American Geophysical Union, Society of Economic Geologists, Clay Minerals Society.

PUBLICATIONS

Journal Articles

- Chamberlain, C.P., and Conrad, M.E., 1991, The relative permeabilities of quartzites and schists at mid-crustal levels: *Geophys. Res. Lett.*, v. 18, p. 959-962.
- Chamberlain, C.P., and Conrad, M.E., 1991, Oxygen isotope zoning in garnet: *Science*, v. 254, p. 403-406.
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- Conrad, M.E., and Naslund, H.R., 1989, Modally-graded rhythmic layering in the Skaergaard intrusion: *J. Petr.*, v. 30, p. 251-269.
- Conrad, M.E., Petersen, U., and O'Neil, J.R., 1992, Evolution of an Au-Ag producing hydrothermal system: The Tayoltita mine, Durango, Mexico: *Econ. Geol.*, v. 87, p. 1451-1474.
- Conrad, M.E., and Chamberlain, C.P., 1992, Laser-based, *in situ* measurements of fine-scale variations in the $\delta^{18}\text{O}$ values of hydrothermal quartz: *Geology*, v. 20, p. 812-816.
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- Macfarlane, A.W., Prol-Ledesma, R., and Conrad, M.E., 1994, Isotope and fluid inclusion studies of the geological and hydrothermal evolution of the Hualgayoc district, northern Peru: *International Geology Review*, v. 36, p. 645-677.
- Ingram, B.L., Conrad, M.E., and Ingle, J.C., in press, Stable isotope variations in estuarine waters: Relation to salinity and freshwater inflow: *Geochim. et Cosmochim. Acta*.
- Thomas, D.M., Paillet, F.L., and Conrad, M.E., in review, Hydrogeology of the HSDP borehole KP-1, Part II: Ground-Water geochemistry and regional flow patterns: *Jour. of Geophys. Research*.

Recent Abstracts

- Conrad, M.E., and Thomas, D.M., 1995, Fluid mixing, boiling and water-rock interaction in the East Rift Zone of Kilauea volcano, Hawaii: *Geol. Soc. Am., Abst. with Prog.*, v. 25, no. 6, p. A203.
- Conrad, M.E., Daley, P.F., Fischer, M.F., Buchanan, B.B., and Leighton, T., 1995, Carbon isotope evidence for subsurface bacterial activity at the Naval Air Station, Alameda, California. *EOS, Trans., Am. Geophys. Union*, v. 76, no. 17, p. S119.
- Conrad, M.E., Karasaki, K., and Freifeld, B., 1994, The use of deuterium-enriched water as a tracer for hydrologic tests: Abstracts of the Eighth International Conference on Geochronology, Cosmochronology and Isotope Geology, U.S. Geological Survey Circular 1107, p. 66.
- Conrad, M.E., Leighton, T., and Buchanan, B.B., 1994, Carbon isotope fractionation by *Bacillus subtilis*. *Geological Society of America Abstracts with Programs*, v. 26, p. A-510.

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Education:

- B.S. Microbiology, 1971, Michigan State University, East Lansing, MI
M.S. Microbiology, 1977, Michigan State University
Thesis: Purification and characterization of an enzyme involved in the metabolism of nitrilotriacetic acid
Ph.D. Soil Science, 1979, Michigan State University
Thesis: Factors influencing the production of nitrous oxide during denitrification.

Research and Professional Experience:

- 1971 - 1979 Research Associate; NSF Graduate Trainee; Michigan State University
Research on: Biodegradation of halogenated anilines and benzoates; biodegradation of nitrilotriacetate (NTA); development of acetylene inhibition technique; design and development of new methodologies for denitrification studies; role of NO and N₂O as denitrification intermediates.
- 1979 - 1990 Lecturer; Assistant Professor; Associate Professor; U.C. Berkeley
Research on: Physiological ecology of soil microorganisms with emphasis on control of C and N transformations and microbial response to environmental stress.
- 1990 - present Professor and Soil Microbiologist, U.C. Berkeley
Research on: Soil microbial C and N dynamics; Soil biophysical controls of atmospherically reactive trace gases; control of microbial biodegradation activity in surface and subsurface soil.
- 1993 - 1995 Chair, Soil Science Department; Head, Ecosystem Sciences Division, Chair, Environmental Science, Policy, and Management Department, U.C. Berkeley.

Recognition:

- 1979 - Emil Truog Award, Soil Science Society of America - outstanding doctoral dissertation
1993 - Boyce Thompson - Distinguished Lecturer in the Life Sciences (Cornell University).
1995 - Fellow - Soil Science Society of America

Classroom Teaching Responsibilities

- 1979-1986 Soil as a Medium for Plant Growth, 5 units/3 units
1979-present Advanced Soil Biology Biochemistry, 2 units
1987-present Soil Microbiology and Biochemistry, lecture and laboratory, 2 units
1991-1993 Global Change Seminar, 2 units

Student Theses Directed:

Dvorak, K. A. 1982. Nitrate control of denitrification in flooded rice soils. M.S. Thesis, University of California, Berkeley, 59 pp.

Strauss, R. B. 1983. Denitrification in a coniferous forest soil. M.S. Thesis, University of California, Berkeley, 57 pp.

Toltschin, N. J. 1985. Isolation and characterization of a fermentative denitrifier. M.S. Thesis, University of California, Berkeley, 58 pp.

Schimel, J. P. 1987. Plant/microbial competition for nitrogen in a California forest and grassland. Ph.D. Thesis, University of California, Berkeley, 156 pp.

Larsen-Woods, J. M. 1987. Adaptation to solute stress by nitrifiers from saline and nonsaline soils. M.S. Thesis, University of California, Berkeley, 75 pp.

Jones, T. M. 1988. The physiological response of soil microorganisms to sudden increases in water potential. M.S. Thesis, University of California, Berkeley, 84 pp.

Hart, S. C. 1990. Control of decomposition processes and nutrient flow in a California forest and grassland. Ph.D. Thesis, University of California, Berkeley, 226 pp.

Soroker, E. F. 1990. Low water content and low water potential as determinants of microbial fate in soil. Ph.D. Thesis, University of California, Berkeley, 146 pp.

Norton, J. M. 1991. Carbon and nitrogen dynamics in the rhizosphere of *Pinus ponderosa* seedlings. Ph.D. Thesis, University of California, Berkeley, 127 pp.

Stark, J. 1991. Environmental factors versus ammonia-oxidizer population characteristics as dominant controllers of nitrification in an oak woodland - annual grassland soil. Ph.D. Thesis, University of California, Berkeley, 146 pp.

Roberson, E. 1991. Extracellular polysaccharide production by soil bacteria: environmental control and significance in agricultural soils. Ph.D. Thesis, University of California, Berkeley, 98 pp.

Holden, P. 1995. The effects of water potential on the biodegradation of a volatile hydrocarbon. Ph.D. Thesis, University of California, Berkeley, 189 pp.

Current Doctoral Students:

Dunkin, K. A.	Microbial community response to chlorinated hydrocarbon, (1996 completion).
Balser, T.	Microbial processes in humification.
Miya, R.	Biodegradation in the rhizosphere.

Post-Doctoral Scholars Supervised:

K. S. Killham, 9/81 - 9/83, Soil microbial response to stress.
T. L. Kieft, 9/83 - 7/85, Energy costs of microbial response to salt stress in soil.
L. Jackson, 9/84 - 7/86, Plant-microbial competition for nitrogen.

P. Rygielwicz, 5/84 - 5/85, Physiological capacities of ectomycorrhizal fungi to utilize organic N-compounds.
 E. A. Davidson, 6/86 - 2/89, Control of soil nitrogen dynamics and trace gas production.
 A. Rudaz, 4/88 - 4/89, Visiting Scholar, Control of denitrification in soil.
 S. Sarig, 8/88 - 10/90, Control of polysaccharide production by soil microorganisms.
 M. Coyne, 8/89 - 12/90, Physiological control of trace N-gas production.
 D. Stegemann, 4/90 - 5/91, Modeling of physical/chemical/biotic control of soil trace gas production.
 A. Schuster, 6/90 - 1/92, Plant-microbial N-dynamics in oak-woodland savannah.
 L. Halverson, 11/91 - 8/95, Microbial ecology of oak-woodland savannah soils.
 J. Jaeger, 8/93 - present, Plant microbial interactions in rhizosphere soil.
 T. Holden, 11/95 - present, Petroleum hydrocarbon biodegradation

Publications (last five years):

Hart, S. C. and M. K. Firestone. 1991. Forest floor-mineral soil interactions in the internal nitrogen cycle of an old-growth forest. *Biogeochem.* 12:103-127.

Norton, J. M. and M. K. Firestone. 1991. Metabolic status of bacteria and fungi in the rhizosphere of ponderosa pine seedlings. *Appl. Environ. Microbiol.* 22:449-455.

Rudaz, A. O., E. A. Davidson and M. K. Firestone. 1991. Sources of nitrous oxide following wetting of dry soil. *FEMS Microb. Ecol.* 85:117-124.

McColl, J. G. and M. K. Firestone. 1991. Soil Chemical and microbial effects of simulated acid rain on clover and soft chess. *Water Air Soil Pollut.* 60:301-313.

Roberson, E. B., S. Sarig, and M. K. Firestone. 1991. Cover crop management of polysaccharide-mediated aggregation in an orchard soil. *Soil Sci. Soc. Am. J.* 55:734-738.

Davidson, E. A., S. C. Hart, C. A. Shanks, and M. K. Firestone. 1991. Measuring gross nitrogen mineralization, immobilization, and nitrification by ^{15}N isotopic pool dilution in intact soil cores. *J. Soil Sci.* 42:335-349.

Roberson, E. B. and M. K. Firestone. 1992. The relationship between desiccation and exopolysaccharide production by a soil *Pseudomonas*. *Appl. Environ. Microbiol.* 58:1284-1291.

Hart, S. C., M. K. Firestone, and E. A. Paul. 1992. Decomposition and nutrient dynamics of ponderosa pine needles in a Mediterranean-type climate. *Can. J. Forest Res.* 22:306-314.

Davidson, E. A., S. C. Hart, and M. K. Firestone. 1992. Internal cycling of nitrate in soils of a mature coniferous forest. *Ecology*, 73:1148-1156.

Davidson, E. A., D. J. Herman, A. Schuster, and M. K. Firestone. 1993. Cattle grazing and oak trees as factors affecting soil emissions of nitric oxide from an annual grassland. pp. 109-119. In: *Agricultural Ecosystems Effects on Trace Gases and Global Change*. ASA Special Publication 70.55. Madison WI.

Hart, S. C., M. K. Firestone, E. A. Paul, and J. L. Smith. 1993. Flow and fate of soil nitrogen in an annual grassland and a young mixed-conifer forest. *Soil Biol. Biochem.* 25:431-442.

Sarig, S., E. B. Roberson and M. K. Firestone. 1993. Microbial activity — soil structure: response to saline water irrigation. *Soil Biol. Biochem.* 25:693-697.

Roberson, E. B., C. Chenu, and M. K. Firestone. 1993. Microstructural changes in bacterial exopolysaccharides during desiccation. *Soil Biol. Biochem.* 25:1299-1301.

Hart, S. C., J. M. Stark, E. A. Davidson, and M. K. Firestone. 1994. Nitrogen mineralization, immobilization, and nitrification. pp. 985-1016. In: *Methods of Soil Analysis, Part 2: Biochemical and Microbiological Properties*. SSSA. Madison WI.

Fukui, R., Schroth, M.N., Hendson, M., Hancock, J.G. and Firestone, M.K. 1994. Growth patterns and metabolic activity of pseudomonads in sugar beet spermospheres: relationship to pericarp colonization by Pythium ultimum. *Phytopath* 84:1331-1338.

Ecological and Social Dimensions of Global Change. 1994. Caron, D., Chapin, F.S., Donoghue, J., Firestone, M, Harte, J., Wells, L.E. and Stewardson, R. Eds. Inst. of Int. Studies U.C. Berkeley.

Stark, J.M. and Firestone, M.K. 1995. Mechanisms for soil moisture effects on activity of nitrifying bacteria. *Appl. Environ. Microbiol.* 61:218-221.

Hunt, J.R., Holden, P.A. and Firestone, M.K. 1995. Coupling transport and biodegradation of VOCs in surface and subsurface soils. *Environ. Health Persp.* 103:75-78.

Stark, J.M. and Firestone, M.K. 1995. Isotopic labelling of soil nitrate pools using nitrogen-15 nitric oxide gas. *Soil Sci. Soc. Am. J.* 59:844-847.

Holden, P.A., J.R. Hunt, and M.K. Firestone. 1995 Unsaturated zone gas-phase VOC biodegradation: the importance of water potential. 50th Purdue Industrial Waste Conference Proceedings: 113-127. Ann Arbor Press.

Roberson, E.B., S. Sarig, C. Shennan and M.K. Firestone. 1996. Nutritional management of microbial polysaccharide production and aggregation in an agricultural soil. *Soil Sci. Soc. Am. J.* 59:(In Press)

Norton, J.M. and M.K. Firestone. 1996 Nitrogen dynamics in the rhizosphere of *Pinus Ponderosa* seedlings. *Soil Biol. Biochem.* (In Press).

Holden, P. A. and M.K. Firestone. 1996. Soil microorganisms in soil cleanup: how can we improve our understanding? *J. Environ. Qual.* (In Press)

CURRICULUM VITAE

JAMES R. HUNT

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Education:

B.S. in Civil and Environmental Engineering, University of California, Irvine, 1972
M.S. in Environmental Engineering, Stanford University, 1973
Ph.D. in Environmental Engineering Science, California Institute of Technology, 1980

Employment:

6/73-9/75 Environmental Engineer, Hydrocomp Inc., Palo Alto, California.
7/80-6/87 Assistant Professor, Department of Civil Engineering, UC Berkeley
7/87-6/94 Associate Professor, Department of Civil Engineering, UC Berkeley
7/94-present Professor, Department of Civil and Environmental Engineering, UC Berkeley
7/89-6/92 Vice Chair, Academic Affairs, Department of Civil Engineering, U.C. Berkeley

Recent Professional Activities:

Registered Civil Engineer in California
Department of Energy Q Clearance
Diplomate of the American Academy of Environmental Engineering
Science Advisory Committee, Environmental Protection Agency Great Lakes - Mid-Atlantic Hazardous Substance Research Center, 1991-1995
National Water Research Institute, Research Advisory Board, 1993-present
National Research Council, Marine Board Committee on Contaminated Marine Sediments, 1993-1996
University of California Water Resources Center, Coordinating Board, 1994-1997

Recent University Activities:

Group Leader of Environmental Engineering Program in the Department of Civil and Environmental Engineering, 1993-present
Elected member of the Berkeley Divisional Council, University of California Academic Senate, 1995-1997

Honors:

1991 Editors' Citation for Excellence in Refereeing - Water Resources Research, American Geophysical Union.
1991 Outstanding Doctoral Thesis Award to advisee Jil T. Geller, Association of Environmental Engineering Professors.

Current Research Projects:

- Transport and Transformation of Volatile Organic Solvents in Unsaturated Soils, National Institute of Environmental Health Sciences 1992-1996 (with M. K. Firestone and L. Alvarez-Cohen).
- Aggregation of Petroleum Hydrocarbons with Particles in Urban Runoff and Estuarine Waters, Interagency Ecological Study Program, San Francisco Bay-Delta, 1993-1996.
- Subsurface Noble Gas Transport at the Nevada Test Site, Los Alamos National Laboratory, 1993-1996.
- In-Situ Reduction of Acid Rock Drainage, University of California Toxic Substances Teaching and Research Program, 1994-1996 (with L. Alvarez-Cohen and F. M. Doyle).
- Microbial Degradation of Petroleum Hydrocarbons in Unsaturated Soils: The Mechanistic Importance of Water Potential and the Exopolymer Matrix, U. S. Environmental Protection Agency, 1994-1996 (with M. Firestone).
- Additional Sampling and Analysis: Sediment Characterization and Treatability Study at Naval Air Station Alameda, California, U. S. Navy, 1996-1997 (with N. Sitar and scientists at LBNL and LLNL)

Patent:

- K. S. Udell, N. Sitar, J. R. Hunt, and L. D. Stewart (1991) Process for in situ decontamination of subsurface soil and groundwater, U. S. Patent No. 5,018,576.

Refereed Publications:

- J. R. Hunt (1980) Prediction of oceanic particle size distributions from coagulation and sedimentation mechanisms. In: Particulates in Water: Characterization, Fate, Effects and Removal, M. C. Kavanaugh and J. O. Leckie, editors, Advances in Chemistry 189, 243-257.
- J. R. Hunt (1982) Self-similar particle size distributions during coagulation; theory and experimental verification, Journal of Fluid Mechanics, 122, 169-185.
- J. R. Hunt (1982) Particle dynamics in seawater; implications for predicting the fate of discharged particles, Environmental Science and Technology, 16, 303-309.
- J. R. Hunt and J. D. Pandya (1984) Sewage sludge coagulation and settling in seawater, Environmental Science and Technology 18, 119-121.
- J. R. Hunt (1986) Particle aggregate breakup by fluid shear. In: Estuarine Cohesive Sediment Dynamics, A. Mehta, Editor, Springer-Verlag, pp 85-109.
- L. M. McDowell-Boyer, J. R. Hunt, and N. Sitar (1986) Particle transport through porous media, Water Resources Research, 22(13), 1901-1921.
- B. E. Logan and J. R. Hunt (1987) Advantages to microbes of growth in permeable aggregates in marine systems, Limnology and Oceanography, 32, 1036-1050.
- A. C. Molseed, J. R. Hunt, and M. W. Cowin (1987) Desalination of agricultural drainage return water I. Operational experiences with conventional and non-conventional pretreatment methods, Desalination 67, 249-262.
- B. E. Logan and J. R. Hunt (1988) Bioflocculation as a microbial response to substrate

limitations, *Biotechnology and Bioengineering*, 31, 91-101.

- J. R. Hunt, N. Sitar, and K. S. Udell (1988) Nonaqueous phase liquid transport and cleanup I. Analysis of mechanisms, *Water Resources Research*, 24, 1247-1258.
- J. R. Hunt, N. Sitar, and K. S. Udell (1988) Nonaqueous phase liquid transport and cleanup II. Experimental studies, *Water Resources Research*, 24, 1259-1269.
- R. W. Buddemeier and J. R. Hunt (1988) Transport of colloidal contaminants in groundwater: radionuclide migration at the Nevada Test Site, *Applied Geochemistry*, 3, 535-548.
- J. R. Hunt (1990) Particle removal by coagulation and settling from a waste plume, In: *Oceanic Processes in Marine Pollution, Volume 6, Physical and Chemical Processes: Transport and Transformation*, D. Baumgartner and I. W. Duedall, editors, R. E. Krieger Publ. Co., Malabar, FL, pp. 109-119.
- R. G. Luthy, D. A. Bella, J. R. Hunt, J. H. Johnson, D. F. Lawler, C. R. O'Melia, and F. G. Pohland (1992) Future concerns in environmental engineering education, *J. Professional Issues in Engineering Education and Practice (ASCE)* 118(4), 361-380.
- J. T. Geller and J. R. Hunt (1993), Mass transfer from nonaqueous phase organic liquids in water-saturated porous media, *Water Resources Research* 29(4), 833-845.
- M. A. Foda, J. R. Hunt, and H.-T. Chou (1993) A non-linear model for the fluidization of marine mud by waves, *Journal of Geophysical Research* 98(C4), 7039-7047.
- H.-T. Chou, M. A. Foda, and J. R. Hunt (1993) Rheological response of cohesive sediments to oscillatory forcing, In: *Nearshore and Estuarine Cohesive Sediment Transport*, Coastal Estuarine Ser. vol. 42, A. J. Mehta, ed., Chpt 8, pp 126-148, American Geophysical Union.
- J. R. Hunt, B.-C. Hwang, and L. M. McDowell-Boyer (1993), Solids accumulation during deep bed filtration, *Environmental Science and Technology* 27(6), 1099-1107.
- J. H. Kessler and J. R. Hunt (1994) Dissolved and colloidal contaminant transport in a partially clogged fracture, *Water Resources Research* 30(4), 1195-1206.
- G. E. Seely, R. W. Falta, and J. R. Hunt (1994) Buoyant advection of gases in unsaturated soil, *Journal of Environmental Engineering* 120(5) 1230-1247.
- C. S. Kao, and J. R. Hunt (in press) Prediction of wetting front movement during one-dimensional infiltration into soils, *Water Resources Research*.

Published Conference Papers

- N. Sitar, J. R. Hunt, and K. S. Udell (1987) Movement of nonaqueous liquids in groundwater, *Proc. Geotechnical Practice for Waste Disposal '87*, Geotechnical Division, ASCE, Ann Arbor, MI, pp. 205-223.
- J. R. Hunt, L. M. McDowell-Boyer, and N. Sitar (1987) Colloid migration in porous media -- an analysis of mechanisms. In: *Coupled Processes Associated with Nuclear Repositories*, C.-F. Tzang, editor, Academic Press, pp. 453-472.
- J. R. Hunt, J. T. Geller, N. Sitar, and K. S. Udell (1988) Subsurface transport processes for gasoline components. 1988 Joint CSCE-ASCE National conference on environmental Engineering, July 13-15, Vancouver, B.C., pp 536-543.
- H. T. Chou, J. R. Hunt, and M. A. Foda (1991) Fluidization of marine mud by waves, *Marine Poll. Bull.* 23, 75-81 (International Conference on Environmental Management of Enclosed Coastal Seas '90, Kobe, Japan, Aug 3-6, 1990).
- N. Sitar, J. R. Hunt, and J. T. Geller (1992) Practical aspects of multiphase equilibria in evaluating the degree of contamination, *Subsurface Contamination by Immiscible Fluids*, K. U. Weyer, ed., Proceedings of International Conference on Subsurface

- Contamination by Immiscible Fluids, April 18-20, 1990, Calgary, Alberta, A. A. Balkema, Rotterdam, pp 265-270.
- J. R. Hunt (1993) Manipulating colloids to change aquifer permeability, moderator's overview. In: Manipulating Groundwater Colloids for Environmental Restoration, J. F. McCarthy and F. J. Wobber, eds., Lewis Publ., Boca Raton, Florida, pp 97-102.
- H. Scott Fogler and J. R. Hunt (1993) Summary and results of group discussion for session III. Manipulating Colloids to change aquifer permeability. In: Manipulating Groundwater Colloids for Environmental Restoration, J. F. McCarthy and F. J. Wobber, eds., Lewis Publ., Boca Raton, Florida, pp 139-150.
- J. R. Hunt, and B.-C. Hwang (1993) The accumulation of solids within deep-bed filters, Proc. 6th World Filtration Conference, Nagoya, Japan, May, 1993, pp. 236-239.
- J. H. Kessler and J. R. Hunt (1993) Open channels in fractures maintained by deposition and erosion of colloids, High Level Radioactive Waste Management Proceedings of the Fourth International Conference, Las Vegas, Nevada, April, 1993, vol. 2, pp 1547-1553.
- J. R. Hunt (1993) Tritiated water as a tracer for water movement through near-surface desert soils, In: Tracers in Hydrology, N. E. Peters, E. Hoehn, Ch. Leibundgut, N. Tase, and D. E. Walling, eds., Proceedings of the Yokohama symposium, July 11-23, 1993, IAHS Publ. No. 215, pp 135-142.
- C. S. Kao and J. R. Hunt (1994) A plug flow model of liquid infiltration into dry soils, In Proceedings of Fourteenth Annual American Geophysical Union Hydrology Days, H. J. Morel-Seytoux, ed., April 5-8, Fort Collins, CO, pp 183-193.
- J. R. Hunt, P. A. Holden, and M. K. Firestone (1995) Coupling transport and biodegradation of VOCs in surface and subsurface soils, Environmental Health Perspectives 103 (Supplement 5), 75-78.
- P. A. Holden, J. R. Hunt, and M. K. Firestone (submitted) Unsaturated zone gas-phase VOC biodegradation: The importance of water potential, Purdue Industrial Waste Conference, May 8-10, 1995, Purdue, IN

January 18, 1996

CURRICULUM VITAE

JOHN P. KNEZOVICH

Group Leader for Ecological Response and Restoration, Health and Ecological Assessment Division, Lawrence Livermore National Laboratory, University of California, Livermore, California.

BIRTH: Sacramento, California, 25 July 1955

FAMILY: Wife: Married (1989) Catherine Ryan
Stockton, California

Children: Mary (1993)
Paul (1995)

ADDRESS: Residence: 1439 Elkhorn Drive
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Business: Lawrence Livermore National Laboratory
University of California
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EDUCATION: University of the Pacific, Stockton, California
B.A. (Biology), 1973-1977

University of California, Davis, California
M.S. (Chemical Ecology), 1978-1980
Ph.D. (Chemical Ecology), 1980-1983

POSITIONS: Group Leader, Ecological Response and Restoration, Health and Ecological Assessment Division, Lawrence Livermore National Laboratory, University of California, Livermore, California, 1993-Present

Senior Scientist,
Environmental Sciences Division, Lawrence Livermore National Laboratory, University of California, Livermore, California, 1986-1993

Postdoctoral Research Staff Member Environmental Sciences Division, Lawrence Livermore National Laboratory, Livermore, California, 1983-1986

Research Assistant, Department of Environmental
Toxicology, University of California, Davis,
California, 1980-1983

Research Assistant, Environmental Sciences Division,
Lawrence Livermore National Laboratory,
University of California, Livermore,
California, 1976-1980

Lecturer, University of California, Santa Cruz

Lecturer, University of California, Los Angeles

Instructor, Hazardous Materials Management Program,
University of California, Santa Cruz

Member, Scientific Planning and Review Committee, Bay
Protection and Toxic Cleanup Program, California State
Water Quality Control Board

Member, Education Committee, Society of Environmental
Toxicology and Chemistry

RESEARCH:

Environmental Chemistry
Aquatic Toxicology
Ecological Risk Assessment

PROFESSIONAL
SOCIETIES:

American Association for the Advancement of Science
American Chemical Society
Genetic and Environmental Toxicology Association of
Northern California
Society of Environmental Toxicology and Chemistry
San Francisco Bay and Estuarine Association
Western Society of Naturalists

HONORS:

C.M. Boye Academic Scholarship
Jastro-Shields Graduate Research Scholarship

BIBLIOGRAPHY

John P. Knezovich, Ph.D.

PUBLICATIONS

1. J.P. Knezovich, *The Influence of Organic Chelators on the Toxicity of Copper to Embryos of the Pacific Oyster, Crassostrea gigas*, M.S. Thesis, University of California, Davis, CA (1980).
2. F.L. Harrison, J.P. Knezovich, and J.S. Tucker, *The Sensitivity of Embryos of the Pacific Oyster Crassostrea gigas to Different Chemical Forms of Copper*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52725 and NUREG/CR-1088 Report (1980).
3. J.P. Knezovich, F.L. Harrison, and J.S. Tucker, "The Influence of Organic Chelators on the Toxicity of Copper to Embryos of the Pacific Oyster, *Crassostrea gigas*," *Arch. Environ. Contam. Toxicol.* 10, 241 (1981).
4. F.L. Harrison, J.P. Knezovich, and D.W. Rice, Jr., *Effects of Copper on Adult and Early Life Stages of the Freshwater Clam, Corbicula manilensis*, Lawrence Livermore National Laboratory/U.S. Nuclear Regulatory Commission Report, UCRL-52741, NUREG/CR-1370 (1981).
5. F.L. Harrison, D.J. Bishop, D.W. Rice, Jr., and J.P. Knezovich, *Copper in the Intake and Discharge Zones of the Surry and Salem Nuclear Power Stations*, Lawrence Livermore National Laboratory/U.S. Nuclear Regulatory Commission Report, UCRL-53325, and NUREG/CR-2965 (1983).
6. F.L. Harrison, D.J. Bishop, D.W. Rice, Jr., and J.P. Knezovich, *Concentration and Distribution of Copper in Effluents from the H.B Robinson Steam Electric Plant*, Lawrence Livermore National Laboratory/U.S. Nuclear Regulatory Commission Report, UCRL-53047, NUREG/CR-3132 (1983).
7. J.P. Knezovich, *The Comparative Disposition of an Aromatic Amine by Marine Molluscs*, Ph.D. Thesis, University of California, Davis, CA (1983).

8. F.L. Harrison, J.P. Knezovich, and D.W. Rice, Jr., "The Toxicity of Copper to the Adult and Early Life Stages of the Freshwater Clam, *Corbicula manilensis*," *Arch. Environ. Contam. Toxicol.* 13, 85-92 (1984).
9. J.P. Knezovich, "Metabolism of Hazardous Compounds by Molluscs," *Energy and Technology Review*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52000-84-7, p. 67 (1984).
10. J.P. Knezovich and D.G. Crosby, "The Fate and Metabolism of *o*-Toluidine in the Marine Bivalve Molluscs *Mytilus edulis* and *Crassostrea gigas*," *Environ. Toxicol. Chem.* 4, 435-446 (1985).
11. J.P. Knezovich and D.G. Crosby, "The Comparative Metabolism of *o*-Toluidine by the Abalone (*Haliotis rufescens*) and Flatfish (*Platichthys stellatus*)," *Environ. Toxicol. Chem.* 5, 387-392 (1986).
12. J.P. Knezovich, F.L. Harrison, and R. Wilhelm, "The Bioavailability of Sediment-Sorbed Organic Chemicals: A Review," *Water, Air Soil Pollut.* 32, 233-245 (1987).
13. J.P. Knezovich and F.L. Harrison, "A New Method for Determining the Concentrations of Volatile Organic Compounds in Sediment Interstitial Water," *Bull. Env. Contam. Toxicol.* 38, 937-940 (1987).
14. F.L. Harrison, J.P. Knezovich, D.W. Rice, Jr., and J.R. Lam, "Distribution, Fate, and Effects of Energy-Related Residuals in Marine Environments," in *Physiological Responses of Marine Organisms to Environmental Stresses*, J.V. Dorigan and F.L. Harrison, Eds. (U.S. Department of Energy, Washington, DC, 1987), Chapter 13, DOE/ER-0317, pp. 251-292.
15. F.L. Harrison and J.P. Knezovich, "Sublethal Effects of Contaminants on the Metabolism of Metals and Organic Compounds in the Bay Mussel," in *San Francisco Bay: Issues, Resources, Status, and Management*. NOAA Estuary-of-the-Month Seminar Series No. 6 (U.S. Department of Commerce, NOAA Estuarine Programs Office, 1987), pp. 107-123.
16. J.P. Knezovich, M.P. Lawton, and F.L. Harrison, "In Vivo Metabolism of Aromatic Amines by the Bay Mussel, *Mytilus edulis*," *Mar. Env. Res.* 24, 89-91 (1988).

17. J.P. Knezovich and F.L. Harrison, "The Bioavailability of Sediment-Sorbed Chlorobenzenes to Larvae of the Midge, *Chironomus decorus*," *Ecotox. Environ. Safety* 15, 226-241 (1988).
18. J.P. Knezovich, "Biodegradation of Organic Contaminants," *Energy and Technology Review*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52000-88-7, p. 69 (1988).
19. J.P. Knezovich, J. Hirabayashi, D. Bishop, and F. Harrison, "The Influence of Different Soil Types on the Fate of Phenol and Its Biodegradation Products," *Chemosphere* 17, 2199-2205 (1988).
20. J.P. Knezovich, M.P. Lawton, and L.S. Inouye, "Bioaccumulation and Tissue Distribution of a Quaternary Ammonium Surfactant in Three Aquatic Species," *Bull. Environ. Contam. Toxicol.* 42, 87-93 (1989).
21. D.J. Bishop, J.P. Knezovich, and D.W. Rice, Jr., *Sorption Studies of VOCs Related to Soil/Ground Water Contamination at LLNL*, Lawrence Livermore National Laboratory, Livermore, CA, UCID-21651 (1989).
22. J.P. Knezovich and J.I. Daniels, "Bioremediation of High-Explosive Wastes in Environmental Media," in *Institutional Research and Development*, G.L. Struble, Ed., Lawrence Livermore National Laboratory, Livermore, CA, UCRL-53689-89, pp. 144-145 (1989).
23. J.P. Knezovich, "The Metabolic Transformation of Aromatic Amines in Marine Bivalves and Implications for Genotoxic Effects," *J. Shellfish Res.* 8, 437-438 (1989).
24. S.R. Hansen, J.P. Knezovich, S.L. Anderson and J.I. Daniels, "Risk Assessment: Coagulant Use at the Kuparuk Seawater Treatment Plant," Final Report, ARCO Alaska, Inc, Anchorage, AK, (December, 1989), pp. 79.
25. R.E. Martinelli, J.P. Knezovich, and F.L. Harrison, "Radiation-Induced DNA Strand Breakage and Repair in the Marine Polychaete *Neanthes arenaceodentata*," *Mar. Env. Res.* 28, 329-332 (1990).
26. J.P. Knezovich, D.J. Bishop, T.J. Kulp, D. Grbic-Galic, and J. Dewitt, "Anaerobic Microbial Degradation of Acridine and the Application of Remote Fiber Spectroscopy to Monitor the Transformation Process," *Env. Toxicol. Chem.* 9, 1235-1243 (1990).

27. J.P. Knezovich and J.I. Daniels, "Biodegradation of High-Explosive Wastes," in *Energy and Technology Review*, (Lawrence Livermore National Laboratory, Livermore, CA, July-August 1990) p. 67.
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Member, Coordinating Board, University of California Water Resources Center, 1988-1994

Member, University of California Water Quality Task Force on Preserving and Enhancing
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Awards and Honors

University of Windsor, Board of Governors Medal in Geological Engineering, 1973

Nat. Sci. and Engrg. Research Council of Canada Postgraduate Scholarship, 1973 and 1975

1984 NSF Presidential Young Investigator Award

Award for Outstanding Service with the Student Chapter, ASCE, 1984, 1985

Ass. of Engrg. Geologists, Douglas R. Piteau Outstanding Young Member Award, 1986

Best Advisor Award, U.C. Berkeley Student Chapter of ASCE, 1988

Best Professor Award, U.C. Berkeley Student Chapter of ASCE, 1991

Walter L. Huber Civil Engineering Research Prize, ASCE, 1993

Patents

Udell, K.S., Sitar, N., Hunt, J.R., and Stewart, L.D. Jr., Process for In-Situ Decontamination
of Subsurface Soil and Groundwater, U.S. Patent No. 5,018,576,

Selected Recent Publications

- Sitar, N., Hunt, J.R. and Geller, J.T., "Practical Aspects of Multiphase Equilibria in Evaluating the Degree of Contamination", Proceedings of the Conference on Subsurface Contamination by Immiscible Fluids, K.U. Weyer ed., Balkema, Rotterdam, 1992, pp. 265-270.
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July 1, 1986 - June 30, 1993	Associate Professor Department of Mechanical Engineering University of California, Berkeley
July 1, 1980 - June 30, 1986	Assistant Professor Department of Mechanical Engineering University of California, Berkeley
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Administration:

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Selected Research:

1995-2000	Principal Investigator, "Thermally Enhanced Soil and Ground Water Clean-up", \$1,700,000, National Institute of Environmental Health Sciences
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1994-95	Principal Investigator, "Experimentation, Analysis and Modeling of Transport During Clean-up of Subsurface Hazardous Wastes - SERDP" \$100,000, Lawrence Livermore National Laboratory.
1992-95	Principal Investigator, "Thermally Enhanced Remediation of Subsurface Contamination", \$1,100,000, National Institute of Environmental Health Sciences

- 1990-92 Principal Investigator, "Field Study of Steam Injection and Vacuum Extraction for the Clean-up of the LLNL Gasoline Spill," \$405,000, Lawrence Livermore National Laboratory
- 1989-91 Principal Investigator, "Development of Steam Injection for *In Situ* Treatment of Hazardous Liquids," \$200,000, Environmental Protection Agency
- 1988-92 Co-Principal Investigator, "Transport and Cleanup of Mixed Liquid Wastes Trapped in Soil," \$1,800,000, National Institute of Environmental Health Sciences
- 1988-89 Principal Investigator, "*In Situ* Remediation of Hazardous Waste Problems with Horizontal Radial Technology," \$100,000, Environmental Protection Agency
- 1987-88 Principal Investigator, "Removal of Nonaqueous Liquid Phase Contaminants from Aquifers by Steam Displacement," \$65,000, U.C. Toxic Substances Research and Teaching Program
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- 1986-87 Principal Investigator, "Feasibility Study of the Decontamination of Gasoline Spills by Pumping," \$37,000, Lawrence Livermore National Laboratory

Patents:

Udell, K. S., Hunt, J. R., Sitar, N., and Stewart, L. D., "Process for *In Situ* Decontamination of Subsurface Soil and Groundwater," U. S. Patent #5,018,576

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PROFESSIONAL EXPERIENCE

Adjunct Assistant Professor and Assistant Researcher, University of
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Research Assistant Professor, University of Maryland, Horn Point Environmental
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Post-doctoral Research Associate, Puget Sound Institute, University of
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Senior Marine Scientist, Science Applications International Corporation,
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Staff Oceanographer, School of Oceanography, University of Washington,
Seattle, Washington. March 1986 to September 1986.

Research Scientist and Assistant Professor of Biology (adjunct), McNeese
State University, Lake Charles, Louisiana. December 1980 to May
1983.

COMMITTEES AND HONORS

United Nations, Food and Agriculture Organization. U.S. delegate to Group of Experts on the Scientific Aspects of Marine Protection (GESAMP) working group on the impacts of coastal mariculture. 1993-present.

California Environmental Protection Agency, Steering Committee for workshops on Environmental Risk Assessment. 1994-1995.

Technical advisory group to the Alaska Department of Environmental Conservation regarding operation of the Alyeska Ballast Water Treatment Plant, Valdez, Alaska. 1989-1995.

International Council for the Exploration of the Sea (ICES). U.S. delegate to the Working Group on the Environmental Impact of Mariculture. 1986-1991.

1989 recipient of the Garrett Horder Memorial Fellowship in recognition of research in the Natural Sciences affecting marine and aquatic environments of Washington State.

PROFESSIONAL SOCIETIES

Society for Environmental Toxicology and Chemistry
Northern California Chapter, Society for Environmental Toxicology and Chemistry
American Geophysical Union
American Society of Limnology and Oceanography
The Oceanography Society

PUBLICATIONS

Capone, D.G., D.P. Weston, V. Miller and C. Shoemaker. (in review). Antibacterial residues in marine sediments and invertebrates following chemotherapy in aquaculture. *Aquaculture*.

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- Plant-Animal Interactions in the Marine Benthos. (D.M. John, S.J. Hawkins and J.H. Price, eds.) Limnology and Oceanography.

INVITED PRESENTATIONS (past five years)

Digestive solubilization of sediment-associated pollutants: in vitro extraction versus in vivo bioavailability. American Society of Limnology and Oceanography. San Diego, California, 1996.

Ecological Risk Assessment: case study of the United Heckathorn Superfund site. Irvine, California, 1995.

Ecotoxicology in aquaculture (plenary presentation). Aquaculture and Water Resources Management, Stirling, Scotland, 1994

Bioaccumulation of hydrocarbons by marine invertebrates and the role of ingestion. California State University at Hayward, 1993.

Environmental issues in aquaculture. University of California at Santa Barbara, 1993.

The significance of dissolved and particulate organic carbon in the uptake of hydrophobic compounds by deposit feeders. American Society of Limnology and Oceanography, Santa Fe, New Mexico, 1992. (Session chair)

Measuring and managing the benthic impacts of mariculture. Huntsman Marine Science Center, New Brunswick, Canada, 1990.

CONTRACTS AND GRANTS (past five years)

Bioavailability of sediment-associated contaminants at the Alameda Naval Air Station. U.S. Navy. 1995-1997. \$170,000 component of a larger award to the University of California. Principal investigator of overall project: J. Hunt.

Further development of an Ampelisca abdita growth test as an indicator of sediment toxicity. San Francisco Estuary Institute. 1995-1996. \$35,000

The use of digestive potential to determine the ecological risk of contaminated sediments. University of California Toxic Substances Research and Teaching Program. 1995-1996. \$25,000. Co-investigator: L. Mayer.

Fate and microbial effects of aquaculture drug residues in the environment. National Oceanic and Atmospheric Administration. 1995-1997. \$172,000. Co-investigator: B. Dixon.

Development of a chronic Ampelisca abdita bioassay as an indicator of sediment toxicity. San Francisco Estuary Institute. 1994-1995. \$27,000.

CONTRACTS AND GRANTS (continued)

San Francisco Bay Regional Monitoring Program, benthic sample processing. San Francisco Estuary Institute. 1994-1995. \$7,000.

Uptake of dissolved and particle-associated toxicants by the Eastern oyster. Maryland Sea Grant. 1992-1994. \$170,000. Co-investigators - D. Penry, R. Newell, J. Baker.

The environmental fate and effects of aquacultural antibiotics. National Ocean and Atmospheric Administration, Saltonstall-Kennedy Program. 1992-1994. \$250,000. Co-investigators - D. Capone, R. Herwig, J. Staley.

Chemical and biological determinants of hydrocarbon bioaccumulation from contaminated sediments. U.S. Environmental Protection Agency, Office of Exploratory Research. 1990-1994. \$275,000. Co-investigators - J. Baker and D. Penry.

An environmental evaluation of fish net-pen culture in Chesapeake Bay and its tributaries. Maryland Department of Natural Resources. 1990-1991. \$20,000.

Pollutant bioaccumulation and community response in the macrobenthos. U.S. Environmental Protection Agency, Region 10. 1989-1990. \$91,000.

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EDUCATION

Ph.D. (Geology), Columbia University, 1989. *Earthquake geology and seismotectonics of the southern San Andreas and related faults, California*
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B.S. (Geology, Environmental Studies), Evergreen College, 1979.

CAREER

Assistant Research Scientist, 1996-, Seismographic Station, University of California, Berkeley, California.
Staff Scientist, 1992-1996, Earth Sciences Division, Lawrence Berkeley Laboratory, Berkeley California.
Postdoctoral Scientist, 1989-92, Earth Sciences Division, Lawrence Berkeley Laboratory, Berkeley California.
Adjunct Instructor, 1989-1990, Department of Geosciences, San Francisco State University, San Francisco, California
Research Geologist, 1987-88, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California.

CURRENT RESEARCH

Stratigraphic, structural and geomorphological records of recent faulting.
Very high resolution seismic reflection imaging of marine, lake and river sediments.
Sediment transport and depositional history, SF Bay-estuary system, California.
Structure and evolution of extensional strike-slip basins.
Lacustrine sedimentary records of Pacific Northwest earthquakes, climate.

CURRENT PROJECTS

"Quaternary Drilling Project, San Francisco, California: Integrated Paleoenvironment and Neotectonic baseline studies" USDOE OBES 1996 (proposed)
"Subsurface Characterization of the Potrero - Ryer Island Blind Thrust System" USGS NEHRP 1996 (recommended for funding)
"Slip-Rate Determination for the Pittsburg -Kirby Hills Blind Thrust Fault" USGS NEHRP/PGE 1996 (recommended for funding)
"High Resolution Imaging of Historical Deposits at Alameda and Mare Island" USN BRAC 1996 (recommended for funding)
"Controls on Pull-Apart Basin evolution: Integrated geological, Geophysical and Modeling Studies," USDOE OBES 1993-5.
"Bay - River Imaging Development for Geological Engineering" Caltrans, 1994-
"Hayward Fault Recurrence Behavior: Trenching Studies, Fremont and Oakland California", USGS NEHRP, (final report) 1994.
"Very High Resolution Profiling of Pacific Coast Faults," USGS NEHRP 1994.

PROFESSIONAL CONTRIBUTIONS

Member, N. California slip-rate working group, US Geological Survey, 1994-.
Member, N. California active fold/blind thrust working group, US Geological Survey, 1994-.
Member, Natural Disaster Reduction Subgroup (National Laboratories) for the President's Technology for a Sustainable Future initiative, 1994-.
Member, Review Panel, USGS NEHRP, 1993-95.
Member, California active fault working group, Int. Lithosphere Program, IUGG, 1993-.
Associate Editor (Tectonics), Conference Proceedings, Second Conference on Earthquake Hazards of the Eastern San Francisco Bay Area, 1991-92.
Member, Field Trip and Publications Committees, Second Conference on Earthquake Hazards of the Eastern San Francisco Bay Area, 1991-92.
Member, Working Group on Probabilities of Earthquakes in the San Francisco Bay Region, National Earthquake Prediction Evaluation Council, 1989-90.

SELECTED PUBLICATIONS

- 1984 Rabinowitz, P.D., M. Rogan, And P.L. Williams, Sediment thickness, mid-Atlantic ridge, 22° to 38°N, in Rabinowitz, P. D. and H. Schouten, eds., *Mid-Atlantic Ridge Between 22° and 38°N*, Atlas 10, Marine Science International, Woods Hole, MA.
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- 1990 Working Group on California Earthquake Probabilities (WGCEP): Dietrich, J.H., C. R. Allen, L.S. Cluff, C.A. Cornell, W.L. Ellsworth, L.R. Johnson, A.G. Lindh, S.P. Nishenko,
- 1990 C.H. Scholz, D.P. Schwartz, W. Thatcher, P.L. Williams, Probabilities of Large Earthquakes in the San Francisco Bay Region, California, *USGS Circ. 1053*, 51pp.
- 1990 Sieh, K.E. and P.L. Williams, Behavior of the southernmost San Andreas fault during the past 300 years, *J. Geophys. Res.*, 95, 6629-6645.
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- 1991 Anima R.J. and P.L. Williams, High-resolution marine profiling in BASIX: complex faulting at major East Bay faults, *EOS Trans. AGU*, 72, 446.
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- 1992 Williams, P.L. and A.M. Hosokawa, Geomorphic features related to the Hayward fault at the University of California at Berkeley, in Taylor, C.L., Hall N.T. and Melody, M. eds., Field Trip Guidebook, Second Conference on Earthquake Hazards of the Eastern San Francisco Bay Area, 65-71.
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- 1992 Williams, P.L., Geological record of southern Hayward fault earthquakes, in Proceedings, Second Conference on Earthquake Hazards of the Eastern San Francisco Bay Area, 1991-92, G. Borchardt, S. Hirschfeld, J. McClellan, P. Williams, and I. Wong, eds., Calif. Div. Mines and Geol. Spec. Pub. 113, 171-179.
- 1992 Williams, P.L., G.C. Jacoby, and B. Buckley, Coincident ages of large landslides in Seattle's Lake Washington, Abstracts with Programs, *GSA Abstracts with Programs*, 24, 90.
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- 1992 Jacoby, G.C., P.L. Williams, and B.M. Buckley, Tree-ring correlation between prehistoric landslides and abrupt tectonic events in Seattle, Washington, *Science*, 258, 1621-1623.
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APPENDIX B

SAMPLING AND ANALYSIS PLAN

SAMPLING AND ANALYSIS PLAN

FOR

INTRINSIC SEDIMENT PROCESSES STUDY OF SITES 2 & 17:
Seaplane Lagoon & West Beach Landfill Wetlands
NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

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3. SAP 2 Sample Collection and Allocation, West Beach Landfill Wetlands

ATTACHMENT

1. Standard Operating Procedures for Intrinsic Sediment Processes

INTRINSIC SEDIMENT PROCESSES SAMPLING AND ANALYSIS PLAN

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) describes the field and laboratory activities to be conducted during the Intrinsic Sediment Processes Study at the Seaplane Lagoon and West Beach Landfill Wetlands sites (2 & 17) at NAS Alameda. The SAP identifies the sampling strategy and rationale, matrix-specific considerations, equipment and devices, preservation of samples, custody procedures and approaches for meeting the study's analytical objectives.

1.1 SAP OBJECTIVES

The sampling and analysis objectives for this project include the following:

- Obtain representative surficial and core sediment samples from selected locations within the Seaplane Lagoon and the West Beach Landfill Wetlands
- Utilize the sediment samples to conduct innovative and conventional chemical, toxicity and other tests described in the Work Plan
- Analyze samples or sample extracts using standard and innovative techniques in order to characterize conditions and chemicals present in the sampling locations
- Interpret the resulting analytical data to determine the intrinsic sediment remediation of the Seaplane lagoon and the West Beach Landfill Wetlands.
- Conduct laboratory testing and field studies of uptake and toxicity of sediment contaminants to benthic invertebrates.

1.2 RELATED DOCUMENTS

BERC has developed program level documents to describe the procedures to be followed on projects implemented under the UCB/Navy partnership agreement. These include:

- Contractor Quality Control Program Plan
- Health and Safety Plan, Volumes I and II
- Standard Operating Procedures
- Standard Quality Procedures

Work at Sites 2 and 17 will be conducted in accordance with the general procedures described in these program documents and more specifically in the Work Plan. The program documents may be updated periodically. The most recent version of each document is maintained in the BERC office and will be maintained at the sites during field operations.

1.3 ORGANIZATION OF THE SAMPLING AND ANALYSIS PLAN

The SAP for the Seaplane Lagoon and West Beach Landfill Wetlands (also referred to as Landfill Wetlands) is divided into six sections. The first Section is the introduction covering objectives, SAP supporting documents and SAP organization. Section 2 summarizes the previous investigations at sites 2 and 17. Field sampling and laboratory analytical methods are discussed in sections 3 and 4, respectively. Section 5 covers quality assurance and quality control (QA/QC) procedures to be used throughout the SAP. Other supporting documents are referenced in the SAP with test-specific QA/QC procedures included in the appropriate sections. Section 6 discusses the Standard Operating Procedures (SOPs) that are included as attachments to this SAP.

2.0 BACKGROUND

Previous investigations at Sites 2 and 17 have been summarized in Section 2 of the Work Plan. The chemicals of interest in the Seaplane Lagoon include trace metals, polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbon materials, and polychlorinated biphenyls (PCBs). The chemicals of concern for the Landfill Wetlands include PAHs and PCBs. There is no information to indicate that volatile organic chemicals (including chlorinated alkanes and alkenes) are present at these sites.

Section 3 of the Work Plan describes the information required for a better understanding of the conditions at the two sites, and to support informed decisions regarding the short and long term risks of remediation options. Sections 4 and 5 of the Work Plan describe the overall sampling approach and the methods that will be used to obtain the needed information. The sections below and the attached SOPs provide details of the procedures that will be employed to provide the required data and information

3.0 FIELD SAMPLING

Surface and core sediment samples will be collected from the locations identified in Tables SAP-1 and SAP-2 for the Seaplane Lagoon and for the West Beach Landfill Wetlands, respectively. The detailed sampling procedures are described in the Standard Operating Procedures. All samples will be collected by trained and experienced technicians and/or professionals.

Surface samples are practically defined by the depth scale of the intended measurements, the type of sampling device employed, and how the sediment is prepared for testing or analysis. For example, the chemical characterization study will evaluate pore water chemistry in surface sediments on a scale of a few millimeters (mm) or centimeters (cm), which is not a practical scale for collection of "surface sediments" for toxicity or bioaccumulation studies. For this reason, the Co-Principal Investigators will each be responsible for overseeing the sampling and sample handling, and then noting the depth of the "surface sediments" in log books and eventually the reports for the respective studies.

Sampling Strategy and Rationale for Seaplane Lagoon

Sediment sampling in the Seaplane Lagoon will be accomplished using several sampling methods. The total sampling program is summarized in Table SAP-1 and in Figure SAP-1a,b; this table references the section of the Work Plan where the methods are discussed and also lists the locations of the samples, the depth of the samples, and the segments of the cores that will be used in the respective studies. As discussed in Section 2 (including Figure 2-6 showing outfall locations) and Section 4 of the Work Plan, the sediments near outfalls G and H on the east side of the lagoon are expected to have the highest chemical concentrations from past releases through the storm drains. The sediments adjacent to outfalls F and R are also considered to have high chemical concentrations due to releases from storm drains. The two locations have been designated GH and FR for the proposed sampling program.

As listed in Table SAP-1, the chemical characterization studies and the transport and transformation studies will use sediment samples from location GH. Toxicity and bioavailability studies as well as measurements of lagoon sediment properties will also include samples from location FR. Additionally, another location midpoint (MP) in the lagoon will be sampled for a toxicity test and for measurement of sediment properties; this midpoint location will be selected based on the acoustic imaging. The cores listed in the fifth column also show that some sediments will be shared among several studies to minimize the sediment coring effort in the lagoon.

All sampling activities discussed below are contingent on the consistency and properties of the sediment as observed during the initial sampling effort (see Section 4 of Work Plan). It is currently

planned that sampling of surface sediments for subsequent extraction of pore water for toxicity testing and TIE measurements will be conducted using a Ponar sampler (see 5.3.1 of the Work Plan and SOP 25.2 and 27). Surface sediment sampling for the SWIC tests will be conducted using a specially designed corer that will obtain a 5 inch deep core sample that will be directly used in the testing apparatus (see Section 5.3.2 and SOP 27.2).

Depending on the sediment properties, it is currently planned to collect 4-inch sediment cores from a boat using a gravity corer with a liner or by pushing a polymer sleeve (acrylic or polycarbonate) into the sediment. The latter method is preferred because it minimizes disturbance of the surficial sediments, but may not be practical for sampling deeper sediments if the sediment is more compacted. It is expected that the sediment core can be held in the sleeve by a sediment plug at the bottom of the sleeve, or that the top of the tube may have to be sealed or under vacuum to hold the core in place. The details of this sampling activity will be determined based on site experience during the initial sampling effort.

As shown in Table SAP-1, 15 cores (deeper than 20 cm) will be collected from location GH. Sampling of this location is planned for an area approximately 12 m by 12 m (or 40 ft by 40 ft) near the seawall adjacent to outfalls G and H. This grid places sampling locations approximately 4 m (or 12 ft) apart so as to minimize disturbance among sampling locations due to sloughing/collapse of coring holes when the sampling sleeve is withdrawn. Additionally, sediment corings will be collected in order of expected sensitivity of disturbance to the planned measurements: sediment cores for chemical characterization will be collected first, followed by samples for transport and transformation studies. The toxicity testing and bioaccumulation studies use sediments in batch scale experiments and are considered less affected by sampling disturbance.

All cores will be collected in the presence of the Co-Principal Investigator responsible for study. The position of each core will be determined using a global positioning system before the core is retrieved. The Project Geologist will then log the sediment core based on observations through the transparent sleeve, and the Co-Principal Investigator will receive the intact core for transport back to the specified laboratory. The Co-Principal Investigator will be responsible for inspection of the core for any disturbance of sediment, any unusual lack of homogeneity, and other aspects related to obtaining core samples for accurate and representative measurements. For example, chemical characterization of pore water and measurements of sediment properties require that the core be maintained in a upright position if the core material is somewhat fluid. A copy of the log will be provided to the CoPrincipal Investigator and lead Principal Investigator for review. Subsequent subsampling of the core for laboratory studies may add detail to the field observations based on closer examinations, and the laboratory will reference the log so that the location of the subsample and its properties can be compared to other sediment core samples.

Sampling Strategy and Rationale for West Beach Landfill Wetlands

Sediment sampling in the West Beach Landfill Wetlands will be limited to the use of (1) the Ponar sampler to obtain sediments for pore water testing, and likely (2) a push coring device to obtain samples for the chemical characterization and intrinsic sediment transformation studies. The total sampling program is summarized in Table SAP-2 and Figure SAP-2; this table references the section of the Work Plan where the methods are discussed and also lists the locations of the samples, the depth of the samples, and the segments of the cores that will be used in the respective studies.

There are no data to indicate that any areas of the perennially ponded areas have higher concentrations of chemicals that would make them of special interest for the proposed studies. Four locations (W1, W2, W3, and W4) in ponded areas will be selected based on discussions with the Navy and PRC as to what areas would be most beneficially studied for use in ecological assessments. The sediment samples for individual studies will then be collected by the appropriate method. As for the Seaplane Lagoon sampling, an initial sampling effort is required to select the

method that gives intact, undisturbed sediment cores for use in the chemical characterization and transformation studies. The current sampling strategy is to collect most samples from a single location, W1, where six cores to a depth of 1 m will be obtained. (Table SAP-2)

A location in the northwest area of the wetlands adjacent to the West Beach Landfill Wetlands will be selected for the vadose zone soil plot studies and for collection of samples for use in measurements of isotope ratios. Compared to the rest of the wetlands, this area of the wetlands shows slightly higher concentrations of PCBs in soils, which may have resulted from erosion of PCBs on soils from the West Beach Landfill. As for the samples from the ponded areas, these locations will be selected in discussions with the Navy and PRC based on data from an ecological risk assessment.

4.0 LABORATORY ANALYTICAL METHODS

This section describes the analytical methods to be used during the Intrinsic Sediment Processes Studies at the Seaplane Lagoon and West Beach Landfill Wetlands. The analytical methods for each study are discussed in the respective SOPs (see Section 6 of this SAP and Attachments). Table SAP-3 summarizes the methods to be generally used in the respective studies. All methods in this Table are from EPA Publication SW 846, Test Methods for Evaluating Solid Waste: Physical and Chemical Methods, Third Edition, including proposed updates of January, 1995. The reporting limits are those that have been developed by the Navy for NAS Alameda projects.

Selected SW 846 methods address sample extraction, digestion, cleanup procedures that will be used for this project. Concentrations ranges are anticipated to be predominantly trace analyses (less than 1000 mg/kg), and the methods selected are appropriate. The quality assurance/quality control (QA/QC) are written into each method and analytical method specific QC are also discussed in each method.

Data Reduction and Validation

Data reduction and reporting procedures, including description of appropriate statistical analyses, will be used. At a minimum, analytical data will be evaluated for the following: Precision, Accuracy, Representativeness, Comparability and Completeness (PARCC) and acceptable probability of error. Considerations will also made for calibration, detection limits, sample holding times, blank contamination avoidance, spike recovery, and confirmation by a second column or GC/MS requirements. Matrix replicates will also be used as directed by the investigators. To ensure understanding of analytical objectives and requirements, all participating laboratories will be audited by the Contractor Quality Control Program Manager prior to the receipt of the initial samples for analyses, and each participating laboratory will be audited quarterly while samples are being processed.

The Role of Analytical Laboratories

The analyses under this project will be performed by a variety of laboratories. Some of these laboratories are certified by the State of California for certain analytes. All participating laboratories will provide BERC with a QA/QC plan and sampling and analysis method documentation. Laboratories ultimately selected will have the technical and equipment capabilities to perform the analyses requested. BERC Principal Investigators plan to use the following laboratories:

- LLNL Environmental Chemistry Laboratory
- LLNL Isotope Sciences Laboratory
- LLNL Geochemistry Group Laboratory & Analytical Laboratory
- Skidaway Institute of Oceanography
- LLNL Environmental Measurements Laboratory

The LBNL and LLNL laboratories are well respected and recognized in the academic and research community for their high quality performance and for implementing the Department of Energy's mission. However, these laboratories are not formally approved by the regulatory agencies or the Navy to provide data for the federal hazardous waste regulatory decision making process. All participating laboratories will be acknowledged by the Navy for performing the proposed studies. As stated above, the Contractor Quality Control Manager will conduct a preaudit and then routine audits of all laboratories as a quality assurance measure. As discussed in Section 7 of the Work Plan, the data from individual studies will not be the singularly critical factor in the decision making process for NAS Alameda, but rather will be used with other data from BERC and PRC to better understand site conditions for more informed decisions on response actions. The documentation of appropriate QA/QC measures, regular audits, and the intended use of the analytical data are then considered sufficient QA criteria for the participating laboratories to perform analyses for this study.

4.1 ANALYTICAL DATA HANDLING AND REPORTS

All raw analytical and instrumental calibration data generated in the laboratory will be kept as hard copies and/or in electronic form in a computer hard drive (with a backup system) and be available for inspections or reviews by interested parties. The stored information will include parameters/analytes, final concentration data, all calibration data, names of analyst(s) and peer reviewer(s), instrumental readout data, calculations and QC data. Analytical reports will include all the information pertaining to the analytical methods and procedures used, sample and QA/QC results, chain of custody documentation, and raw data as specified in the QA/QC section. The aim of the QA/QC is to identify and implement correct methodologies which limit the introduction of error into the analytical procedures.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

Section 7 of the Work Plan presents general QA/QC considerations; the EPA method for the analysis of priority pollutants includes detailed QC procedures and requirements. These guidelines will be followed throughout the chemical analysis. General QC procedures will include the analysis of a procedural blank and a matrix spike along with every 20 samples processed. To measure analytical precision, at least one sample will be analyzed in triplicate for every 20 samples analyzed. The standard deviation and coefficient of variation will be reported. In addition, recoveries of surrogate spikes will be documented and all analytical instruments calibrated at least daily. All calibration data will be reviewed by the laboratory manager or other qualified laboratory personnel. As appropriate, standard reference materials (SRM) available from commercial sources, will also be routinely analyzed to determine analytical accuracy.

Data Quality Information

Data quality objectives (DQOs) include the anticipated use for samples taken, determines the types of laboratory analysis used; sensitivity of the analytical techniques; detection limits; confidence limits; and precision, accuracy, representativeness, completeness, and comparability (PARCCs). An appropriate sampling design is critical for the resulting data quality. The criteria by which data accuracy and precision are judged constitute the QA/QC requirements discussed in Section 7 of the Work Plan.

Analytical Information Required for Reporting

The following is a summary of analytical information required for reporting data generated during this study:

- All analytical results for each sample taken (raw data may be requested under certain circumstances), in addition to documents that summarize data

- Detection and quantitation limits for all analytical data
- Description of the level of QA/QC used and copies of the QA/QC results and data validation reports
- Blank and spike sample results (specify lab or field samples)
- Care and decontamination of tools, instruments, and sampling equipment in the field to prevent cross-contamination of samples
- Sample preservation and storage protocols and holding times
- Total concentrations of analytes of interest and concentrations of parameters required for the ancillary investigations
- The sampling approach for the Seaplane Lagoon and the West Beach Landfill Wetlands is discussed in Section 4 of the Work Plan.

6.0 STANDARD OPERATING PROCEDURES

Detailed procedures documenting the purpose, objectives, references, procedures and analysis methods, and other topics related to experimental procedures have been formulated as Standard Operating Procedures (SOPs) for this SAP, and are included as attachments to this SAP. In several instances, detailed procedures are available in literature and this material is included in an SOP for attachment rather than duplicating the text in an SOP. SOP 24.4, Isotope Monitoring, that will be conducted as part of the transformation studies (see Section 5.6.2), has already been submitted as part of the Intrinsic Remediation Work Plan (Delivery Order 4) and is not included in these SOPs. Additionally, two proposed studies to assess hydrologic conditions in the Seaplane Lagoon and in the Landfill Wetlands require site specific information not currently available. The proposed studies are discussed in sections 5.5.3 and 5.5.4 of the Work Plan. Because some of the procedures are in development and may require revisions, any substantial changes that may affect the use of the data will be reported to the Contractor Quality Control Program Manager; changes may also be discussed during the quarterly laboratory audits. These revisions in the SOPs will be reviewed by the Contractor Quality Control Program Manager and communicate to the Navy on at least a quarterly schedule.

**TABLES
&
FIGURES**

TABLE SAP-1
Sampling and Analysis Plan
Sediment Coring Schedule
Seaplane Lagoon (Site 17)
 (page 1 of 2)

Chemical Characterization of Pore Water and Sediments						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D. ¹	Sample Depth	* Segment Interval
5.2.1	Microelectrode Measurements in Sediment Core Pore Waters	1-GH	2	GH-CC-C1 GH-CC-C2 Duplicate	20 cm	-
5.2.2	Pore Water Constituent Measurements	1-GH	2	GH-CC-C3 GH-CC-C4 Duplicate	50 cm	2 to 5 cm
5.2.3	Sediment Bulk Mineralogical and Chemical Analyses	1-GH	1	GH-CC-C5	2 m	20 cm
5.2.4	Sediment Metal Speciation Analyses	1-GH	1	Sample from Section 5.2.3 to be tested	2 m	TBD

Pore Water and Sediment Toxicity Tests						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D. ¹	Core Depth	* Segment Interval
5.3.1	Surface Sediment Pore Water Toxicity Tests	3-GH,FR,MP	1	GH-TT-P1 FR-TT-P2 MP-TT-P3	Surface sample	Surface
5.3.2	Surface Sediment/Water Interface Corer (SWIC) Test	3-GH,FR,MP	4	GH-TT-S1 FR-TT-S5 MP-TT-S9 GH-TT-S2 FR-TT-S6 MP-TT-S10 GH-TT-S3 FR-TT-S7 MP-TT-S11 GH-TT-S4 FR-TT-S8 MP-TT-S12	Surface sample	Surface
5.3.2	Subsurface Sediment/Water Interface Corer (SWIC) Test	2-GH,FR	4	GH-TT-C1 FR-TT-C5 GH-TT-C2 FR-TT-C6 GH-TT-C3 FR-TT-C7 GH-TT-C4 FR-TT-C8	3 m	1 m
5.3.3	Pore Water Toxicity Identification Evaluation (TIE)	3-GH,FR,MP	1	Water Samples from Section 5.3.1 to be tested	Surface Sample	Surface
5.3.4	Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metal (SEM)	3-GH,FR,MP 2-GH,FR	4	Sediment Samples from Section 5.3.2 to be tested	Surface and core to 3 m	-

Bioavailability Evaluation						
Reference Section	Task	Sampling Location ¹	Samples per Location	Sample I.D. ¹	Sample Depth	* Segment Interval
5.4.1	Bivalve Test	2-GH,FR	1	GH-BE-C1 FR-BE-C1	Surface (0.5 m)	-
		3-GH,FR,MP	4	Samples from Section 5.3.2 (SWIC Test) to be tested	Core to 3 m	1 m and 2 m
5.4.2	Digestive Fluid Extraction	2-GH,FR	1	Split Samples from Section 5.4.1 above to be tested	Surface (0.5 m)	
		3-GH,FR,MP	4	Samples from Section 5.3.2 to be tested	Core to 3 m	1 m and 2 m

TABLE SAP-1
Sampling and Analysis Plan
Sediment Coring Schedule
Seaplane Lagoon (Site 17)
 (page 2 of 2)

Transport Processes Assessment						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D. ¹	Core Depth	* Segment Interval
5.5.1	Lead-210 Profile in Sediment	1-GH	2	GH-TP-C1 GH-TP-C2 Duplicate	3 m	20 cm
5.5.2	Measurement of Lagoon Sediment Properties	3-GH,FR,MP	2	GH-TP-C1 FR-TP-C3 MP-TP-C5 FR-TP-C4 MP-TP-C6 Sample from Section 5.5.1 also to be tested	3 m	1 m

Intrinsic Transformation Processes						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D. ¹	Sample Depth	* Segment Interval
5.6.1	Fingerprinting of PAHs, PCBs, Hydrocarbons and Hydrocarbon Tracers	1-GH	2	Samples from Section 5.5.1 to be tested	3 m	20 cm
5.6.2	Sources of Transformation Products Using Isotope Measurements	1-GH	2	Samples from Section 5.5.1 to be tested	3 m	-
5.6.3	Intrinsic Production of Methane in Anaerobic Lagoon Sediments	1-GH	1	GH-IT-C1	2 m	20 cm
5.6.4	Intrinsic Transformation of PAHs and PCBs in Anaerobic Lagoon Sediments	1-GH	4	GH-IT-C2 GH-IT-C3 GH-IT-C4 GH-IT-C5	1 m	0.5 - 1 m
5.6.5	Constraints on Transformation of PAHs and PCBs in Anaerobic Lagoon Sediments	1-GH	4	Samples from Section 5.6.4 to be tested	1 m	0 - 0.5 m

Processes in Disturbed Sediment Systems						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D. ¹	Sample Depth	* Segment Interval
5.7.1	Leachate Characterization from Disturbed Seaplane Lagoon Sediments	1-GH	1	Sample from Section 5.2.3 to be tested	Surface sample	-
5.7.2	Toxicity of Disturbed Sediments	3-GH,FR,MP 2-GH,FR	4	Samples from Section 5.3.2 to be tested	Surface and core to 3 m	-

NOTES: 1. Sampling Identification as follows (XX-YY-Z#):

XX: Sampling Location

GH-Outfall Area

FR-Outfall Area

MP-Midpoint Area
between Outfalls

YY: Section Description

CC-Chemical Characterization of Pore Waters and Sediments

TT-Pore Water and Sediment Toxicity Tests

TP-Transport Processes Assessment

IT-Intrinsic Transformation Processes

Z#: Sample Medium

C-Sediment Core

P-Pore Water

S-Surface Sediment

TBD: To Be Decided

2. Additional reference samples will also be obtained from other Bay sites (see Sec 5.4).

^{*} Segment Interval to be used in the laboratory studies

TABLE SAP-2
Sampling and Analysis Plan
Sediment Coring Schedule
West Beach Landfill Wetlands (Site 2)

Chemical Characterization of Pore Water and Sediments						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D.	Core Depth	* Segment Interval
5.2.1	Microelectrode Measurements in Sediment Core Pore Waters	1-W1	2	W1-CC-C1 W1-CC-C2 Duplicate	20 cm	-
5.2.2	Pore Water Constituent Measurements	1-W1	2	W1-CC-C3 W1-CC-C4 Duplicate	50 cm	2 to 5 cm
5.2.3	Sediment Bulk Mineralogical and Chemical Analyses	1-W1	1	W1-CC-C5	1 m	20 cm
5.2.4	Sediment Metal Speciation Analyses (if applicable)	1-W1	1	Sample from Section 5.2.3 to be tested	1 m	-

Pore Water and Sediment Toxicity Tests						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D.	Core Depth	* Segment Interval
5.3.1	Surface Sediment Pore Water Toxicity Tests	4-W1,W2, W3,W4	1	W1-TT-P1 W2-TT-P2 W3-TT-P3 W4-TT-P4	Surface sample	-
5.3.3	Pore Water Toxicity Identification Evaluation (TIE)	4-W1,W2, W3,W4	1	Water Samples from Section 5.3.1 to be tested	Surface sample	-
5.3.4	Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metal (SEM)	4-W1,W2, W3,W4	1	Sediment Samples from Section 5.3.1 to be tested	Surface sample	-

Bioavailability Evaluation						
Reference Section	Task	Sampling Location ^a	Samples per Location	Sample I.D.	Core Depth	* Segment Interval
5.4.1	Bivalve Test	3-W1,W2, W3	4	W1-BE-S1 W2-BE-S5 W3-BE-S9 W1-BE-S2 W2-BE-S6 W3-BE-S10 W1-BE-S3 W2-BE-S7 W3-BE-S11 W1-BE-S4 W2-BE-S8 W3-BE-S12	Surface sample	-
5.4.2	Digestive Fluid Extraction	3-W1,W2, W3	4	Samples from Section 5.4.1 to be tested	Surface sample	-

Intrinsic Transformation Processes						
Reference Section	Task	Sampling Location	Samples per Location	Sample I.D.	Core Depth	* Segment Interval
5.6.1	Fingerprinting of PAHs, PCBs, Hydrocarbons and Hydrocarbon Tracers	1-W1	1	W1-IT-C1	1 m	20 cm
5.6.2	Sources of Transformation Products Using Isotope Measurements	1-W1	1	W1-IT-C2	1 m	-
5.6.4	Intrinsic Transformation of PAHs and PCBs in Anaerobic Wetland Sediments	1-W1	4	W1-IT-C3 W1-IT-C4 W1-IT-C5 W1-IT-C6	1 m	-

NOTES: 1. Sampling Identification as follows (XX-YY-Z#):

XX: Sampling Location

W1-To Be Determined

W2-To Be Determined

W3-To Be Determined

W4-To Be Determined

YY: Section Description

CC-Chemical Characterization of Pore Waters and Sediments

TT-Pore Water and Sediment Toxicity Tests

BE-Bioavailability Evaluation

IT-Intrinsic Transformation Processes

Z#: Sample Medium

C-Sediment Core

P-Pore Water

S-Surface Sediment

2. Additional reference samples will also be obtained from other Bay sites (see Sec 5.4).

* Segment Interval to be used in the laboratory studies

Table SAP-3 Analysis Plan for Intrinsic Sediment Processes Project

EPA Method	Analytes/ Parameters	Instrumental Techniques	Navy Reporting Limits:	Container Type	Preservation	Max. Holding Time
4500F	Ammonia	Selective electrode	NA	P,G	Cool to 4°C	24 hours
120.1	Specific conductance (Conductivity)	Electrometric	NA	P, G	Cool to 4°C	24 hours
9050	Resistivity (1/Conductivity)	Electrometric	1 mg/kg	P, G	Cool to 4°C	28 days
6010	Cadmium	ICP	2 mg/kg	P, G, C	Cool to 4°C HNO ₃	6 months
6010 7171	Chromium	ICP; AAS	5 mg/kg	P, G, C	Cool to 4°C HNO ₃	6 months
6010	Copper	ICP	1 mg/kg	P, G, C	Cool to 4°C HNO ₃	6 months
6010, 7420	Lead	ICP; AAS	0.1 mg/kg	P, G, C	Cool to 4°C HNO ₃	6 months
7471	Mercury	AAS	8 mg/kg	P, G, C	Cool to 4°C HNO ₃	6 months
6010	Nickel	ICP	4 mg/kg	P, G, C	Cool to 4°C HNO ₃	6 months
6010	Zinc	ICP	8 mg/kg	P, G, C	Cool to 4°C HNO ₃	6 months
300.0	Nitrate		3.3 µg/kg	P, G	Cool to 4°C	7 day/ 40 days
8080	PCBs	GC; GC/MS	3.3 µg/kg	P, G	Cool to 4°C	7 day/ 40 days
8080	DDD	GC; GC/MS	3.3 µg/kg	P, G	Cool to 4°C	7 day/ 40 days
8080	DDE	GC; GC/MS	3.3 µg/kg	P, G	Cool to 4°C	7 day/ 40 days
8080	DDT	GC; GC/MS	3.3 µg/kg	P, G	Cool to 4°C	7 day/ 40 days
9045C; 9040B	pH	Electrometric		P, G	NA	
9310	Radionuclides Isotope ratios			P,G		
300.0	Sulfate		1.0 mg/kg	P,G		28 days
9030	Sulfides	Colorimetric	5 mg/kg	P,G	Cool to 4°C	
8310	Polynuclear Aromatic Hydrocarbons (PAHs)	GC; GC/MS HPLC		P,G	Cool to 4°C	7 days/ 40 days
9060	Total Organic Carbon (TOC)	GC	NA	P,G	Cool to 4°C	28 days
8015 modified	Total Petroleum Hydrocarbon (TPH)	GC; GC/MS		P,G	GC; GC/MS	

P = Plastic (usually polyethylene)

G = Glass

C = Core

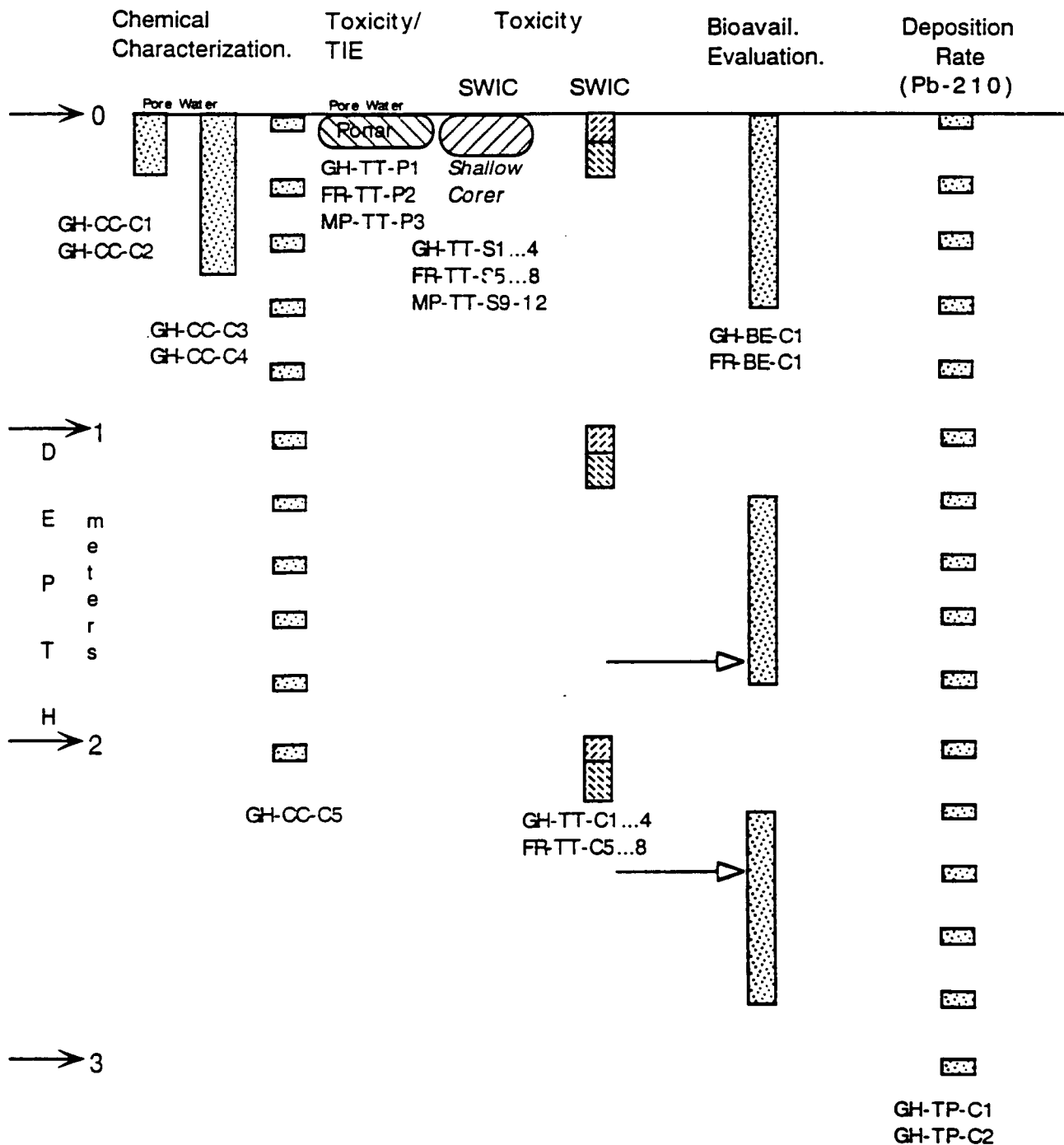


Figure SAP-1a. Sample Collection and Allocation for Seaplane Lagoon (see Table SAP-1 for sample location designations)

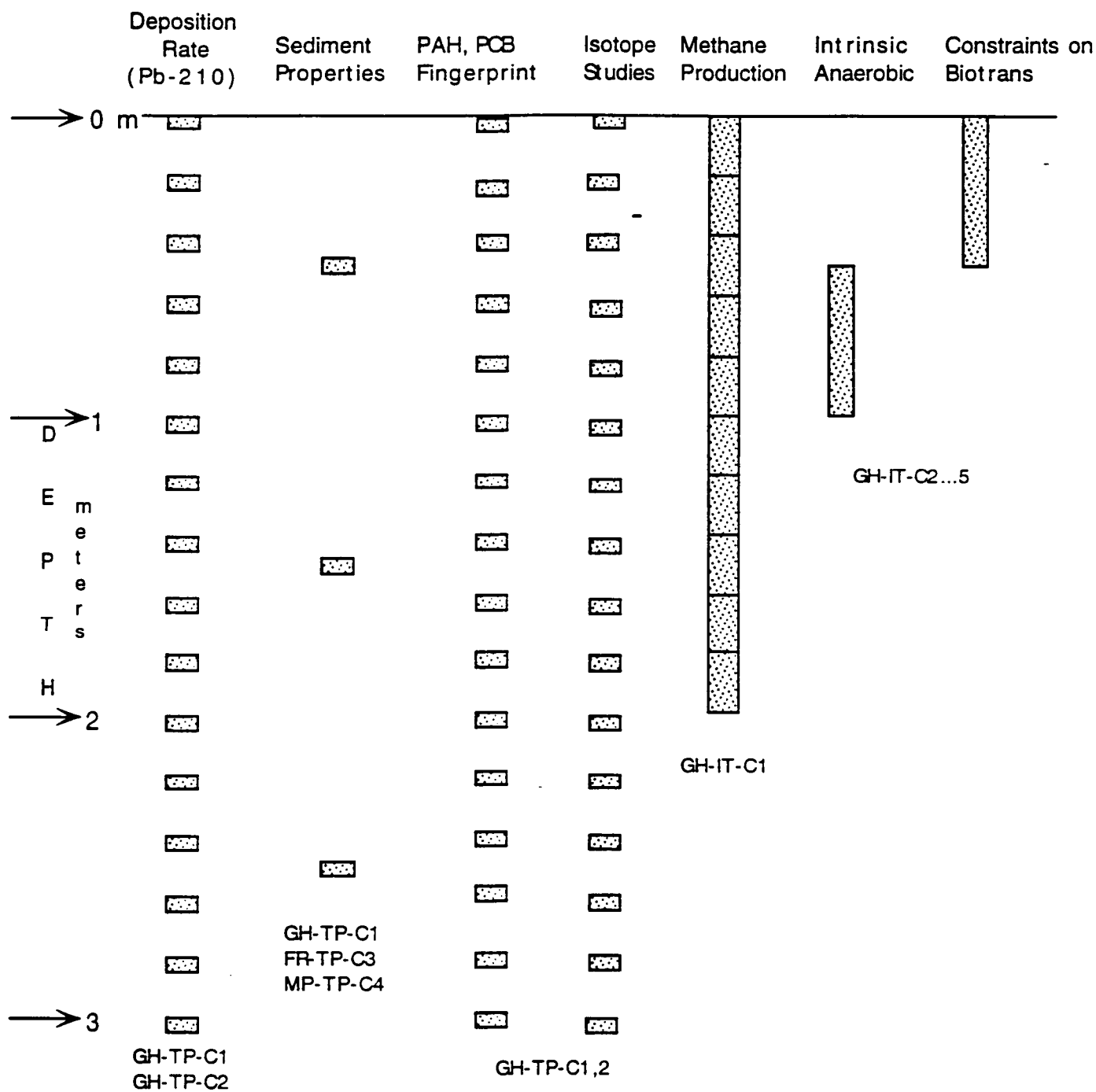


Figure SAP-1b. Sample Collection and Allocation for Seaplane Lagoon, continued (Note: Deposition Rate Pb-210 is repeated for comparison with Figure SAP-1a)

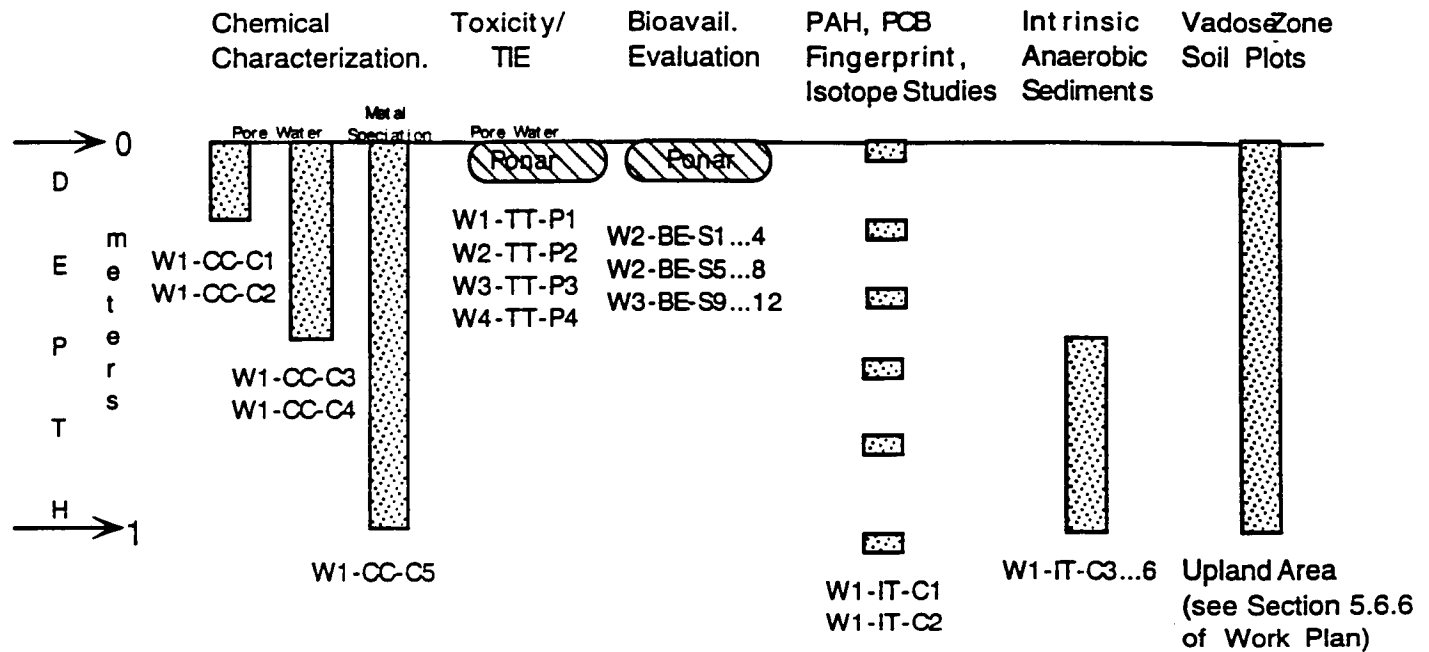


Figure SAP-2. Sample Collection and Allocation for West Beach Landfill Wetlands (see Table SAP-2 for sample location designations)

**STANDARD OPERATING
PROCEDURES
FOR
INTRINSIC SEDIMENT
PROCESSES**

LIST OF STANDARD OPERATING PROCEDURES

Sediment Coring Procedures	25.1
Sediment Sampling for Pore Water Extraction	25.2
Pore Water Isolation	25.3
Acoustic Imaging of Sediments	25.4
Microelectrode Measurements in Sediment Core Pore Waters	26.1
Pore Water Constituent Measurements	26.2
Sediment Bulk and Mineralogical Analyses	26.3
Sediment Metal Speciation Analyses	26.4
Pore Water Toxicity Test	27.1
Sediment Water Interface Core Test (SWIC)	27.2
Toxicity Identification Evaluations	27.3
Acid Volatile Sulfides and Simultaneously Extracted Metals	27.4
Bioavailability/Bioaccumulation by the Bivalve	28.1
Digestive Fluid Extraction	28.2
Lead-210 Profile in Sediment	29.1
Measurement of Lagoon Sediment Properties	29.2
Fingerprinting PAHs, PCBs, Hydrocarbons and Hydrocarbon Tracers	30.1
Intrinsic Production of Methane in Anaerobic Lagoon Sediments	30.2
Intrinsic Transformation of PAHs and PCBs in Anaerobic Sediments	30.3
Constraints on Transformation of PAHs and PCBs in Anaerobic Sediments	30.4
Transformation of PAHs and PCBs in Vadose Zone Soil Plots	30.5
<i>Leaching From Disturbed Sediments</i>	<i>26.5</i>

SEDIMENT CORING PROCEDURES

STANDARD OPERATING PROCEDURE 25.1

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the sediment coring procedure to be used to collect sediment samples from Seaplane Lagoon and West Beach Landfill Wetlands.

2.0 OBJECTIVE

To describe a procedure for collecting core sediment samples of good integrity to be used in various sediment tests including physical/chemical characterization, sediment and pore water toxicity; toxicity identification evaluation, metal speciation, bioavailability evaluation, transport processes, and sediment properties.

3.0 REFERENCES

- Glew, J.R. 1988. A Portable Extruding Device for Close Interval Sectioning of Unconsolidated Core Samples. *J. Paleolim.* 1:235-239.
Glew, J.R. 1989. A New Trigger Mechanism for Sediment Samplers. *J. Paleolim.* 2. 241-243.
Glew, J.R. 1991. Miniature Gravity Corer for Recovering Short Sediment Cores. *J. Paleolim.* 5: 285-287.

4.0 SPECIAL EQUIPMENT

Specialized equipment include: a gravity corer and extruder; a mini corer and extruder; a Lexon coring tubes and rubber stoppers.

5.0 PROCEDURES

1. Sediment cores from Seaplane Lagoon and West Beach Landfill Wetlands may be collected using a gravity corer. The corer is equipped with a modified trigger mechanism and adapted to hold a polymer sleeve. The sleeve provides sufficient sediment material for measuring sediment toxicity, bioaccumulation, chemical and physical properties, and sediment dating and all other tests specified in this SAP.
2. Attempts will be made to collect sediment cores > 2 m in length.
3. The cores will be taken from the sampling points designated in Section 3 of this SAP and Section 4 of the Work Plan

4. Before inserting the core sleeve in the corer, the top edge of the sleeve will be inspected for damage: it is important that the core sleeve has a smooth, un-deformed edge to mate with the seal ring.
5. Check the position of the seal ring in the corer. A small amount of silicone grease may be used to retain the seal ring and to ensure a good seal. Sediment samples in contact with this material will not be used for any analysis.
6. The gravity corer will be lowered slowly in the water, allowing it to sink in the sediment by its own weight, while keeping tension on the rope.
7. Once the corer has penetrated the sediment to the required depth, a messenger is delivered down the coring line, which triggers the closing of the corer, and effectively seals the top of the core sleeve.
8. Once triggered, the corer will be gently retrieved to just below the lagoon water surface. Then, holding the corer upright by one hand, a sliding plug will be placed at the bottom of the core.
9. When placing the plug into the core sleeve, the core sleeve will remain submerged to avoid the loss of sediment; the crew member must extend an arm into the water to accomplish this procedure.
10. The plug used here will be the same one that will be used to extrude the core, as necessary.
11. A stopper will be placed under the sliding plug to seal the core. The stopper is slightly bigger in size than the sliding plug, and will be removed before the core sleeve is mounted in the sectioner.
12. While keeping the core tube upright in the boat or raft, the corer will be disengaged from the coring sleeve, and the top of the core sleeve is closed by another stopper.
13. Support for the stopper will be maintained so the sediment does not fall out of the coring sleeve.
14. In the boat, the core should always be kept upright in a stand to keep the sleeve vertical.
15. A smaller corer with smaller diameter sleeve which operates in a similar fashion as described above can be used to retrieve short cores.
16. Sediment cores will be sectioned at the laboratory soon after they are retrieved or before using for the various tests.
17. The following steps are involved in core sectioning: Measure the length of the core using a meter stick; note the depth and nature of any interesting changes visible in the stratigraphy; with the extruder push rod retracted completely, remove the lower stopper and insert the core sleeve in the clamping sleeve; tighten the sleeve clamp.
18. Remove the upper stopper and attach the tray; water can now be siphoned off the sample or alternatively it may be displaced by extrusion.
19. Push the core tube down over the push rod to drive the core up to the top of the sleeve.

20. With the sample at the level of the tray, place the calibrated cylinder over the core and push the upper 1 cm. of sediment into the cylinder.
21. Slide off the cylinder and bag the sample. Extrude and discard the center portion of the core.
22. To avoid contamination, the lower sample should be taken 1 cm. above of the bottom of the core.
23. Place the sediment samples in tightly sealed, clean, polyethylene bags (18 ounce size).
24. The labeling of each bag will include: site name, sample depth, and the date when the sample was collected.
25. No preservatives or chemicals are added to sediment samples.
26. Samples are stored in small plastic bags in plastic insulated boxes at cold temperature (4°C; not frozen) to prevent evaporation.
27. Complete records are maintained to identify and track sediment samples. These include field and coring data forms, as well as custody forms.

6.0 ANALYTICAL PROCEDURES

Analyses will be performed in accordance with other SOPs.

7.0 HEALTH & SAFETY

During the implementation of this SAP, safety and health considerations will be included. A separate Health and Safety Plan (HSP) has been prepared for this project which contain routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulation. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

SEDIMENT SAMPLING FOR PORE WATER EXTRACTION

STANDARD OPERATING PROCEDURE 25.2

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes collection of surficial sediment samples from Seaplane Lagoon and West Beach Landfill Wetlands to be used for pore water extraction. This procedure is applicable to BERC and subcontractor personnel involved in collection of environmental samples and performance of specific test required under this study.

2.0 OBJECTIVE

The objective of the procedure is to collect surficial sediment samples used for providing pore water samples.

3.0 REFERENCES

American Public Health Association (APHA). 1995. *Standard Methods for the Examination of Water and Wastewater*. 19th Edition., Washington, DC.

4.0 SPECIALIZED EQUIPMENT

No special equipment are required for this SOP.

5.0 PROCEDURES

1. Surficial sediments will be acquired by Ponar samples (or dredge) from sites in Seaplane Lagoon, from sites within the West Beach Landfill Wetlands, and from sites in San Francisco Bay adjacent to the West Beach Landfill Wetlands. Approximately 10 liters of sediment will be acquired from each of these sites.
2. Sediment cores will also be obtained for the evaluation of acid volatile sulfides and simultaneously extracted metals. These 10-cm deep cores will be obtained in parallel with the 10 surficial bulk (e.g., dredged) samples described above.

Sediment Storage

1. Bulk sediment that is collected from the cores will be stored in sealed plastic containers at 4°C. Headspace will be kept to a minimum to prevent oxidation and volatilization of compounds.

2. In accordance with EPA guidelines, sediment samples will be used in TIE evaluations no longer than 14 days from the time of collection (Ankley *et al.*, 1991).

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories acceptable to the Navy. Analytical methods used are listed in Table 5-2 and are referenced in the EPA publication SW 846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

During the implementation of this SAP, safety and health considerations will be included. A separate Health and Safety Plan (HSP) has been prepared for this project which contain routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

PORE WATER ISOLATION

STANDARD OPERATING PROCEDURE 25.3

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the isolation of pore water from the sediment samples from Seaplane Lagoon and Wet Beach Landfill Wetlands. This procedure is applicable to BERC and subcontractor personnel involved toxicity testing and toxicity identification evaluation.

2.0 OBJECTIVES

The objective of this task is to describe the isolation of pore water from sediment samples using centrifugation for sediment toxicity tests at Seaplane Lagoon and the West Beach Landfill Wetlands.

3.0 REFERENCES

None.

4.0 SPECIALIZED EQUIPMENT

No special equipment are required for this SOP.

5.0 PROCEDURES

1. Un-homogenized sediment is placed in 250-ml plastic bottles and centrifuged at 2,500 x g at 4°C for 20 minutes. Pore water is subsequently decanted, passed through a 1- μ mesh Nitex screen, and is stored in an acid-washed plastic bottle at 4°C for a maximum of 24 hours prior to use.

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories approved by the Navy. Analytical methods use are listed in Table SAP-3 and are referenced in the EPA publication SW 846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

During the implementation of this SAP, safety and health considerations will be included. A separate Health and Safety Plan (HSP) has been prepared for this project which contain routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

ACOUSTIC IMAGING OF SEDIMENTS

STANDARD OPERATING PROCEDURES 25.4

1.0 PURPOSE

This procedure describes the acoustic imaging activity that will be conducted in the Seaplane Lagoon and at the southern and western perimeter seawall of the West Beach Landfill Wetlands.

2.0 OBJECTIVES

The objectives of the acoustic imaging procedure areas are as follows:

- Characterize fine details of shallow sediment stratigraphy and morphology

- Provide an objective rationale for sedimentation rates to be extrapolated across the site(s)

- Enhance and constrain interpretive vertical lithology mapping and characterization of major sediment units and candidate fast-path transport features in the upper 100 feet of section.

- Incorporate acoustic imaging data and lithological borehole data to construct pre-base geography and paleogeography models in order to predict lateral geometries, extent and variability of major sediment units.

3.0 REFERENCES

Anima R. J., P. L. Williams and J. McCarthy, 1992. High-resolution Marine Seismic Reflection Profiles Across East Bay Faults, in Proceedings, Second Conference on Earthquake Hazards of the Eastern San Francisco Bay Area, 1991-92, G. Borchardt, S. Hirschfeld, J. McClellan, P. Williams, and I. Wong, eds., Calif. Div. Mines and Geol. Spec. Pub. 113,18.

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Williams, P., P. Taylor, R. Wilhelms, and R. Buell. 1995. The BRIDGE Project: High-Resolution seismic Reflection Study for the Caltrans Toll Bridge Retrofit Program, Abst. w/prog., AEG/GRA Annual Meeting.

Williams, P. L. 1995 Seismic Stratigraphy and Bedrock Depth, Eastern Span, San Francisco - Oakland Bay Bridge, Caltrans BRIDGE Project Report.

Williams, P. L., R. Anima, L. Ingram, J. McCarthy, T. McEvilly, T. Nakata, M. Okamura, and K. Shimazaki. 1996. Geometry and Holocene Activity of the Pinole and Southernmost Rodgers Creek faults, San Pablo Bay, California, (submitted to Geol. Soc. Am. Bulletin).

4.0 SPECIALIZED EQUIPMENT

The equipment to be used in this procedure is described under experimental procedures.

5.0 EXPERIMENTAL PROCEDURES

1. VHR profiling involves the transmission, sensing, and recording of sound energy emitted from an acoustic source towed behind a vessel. The combination of VHR profiling, GPS navigation, and Macintosh-hosted images interpretation and map preparation provides a system for the study of shallow marine deposits.
2. The maximum recording depth of the VHR system to be employed in this study is about 300 feet, with specific experience in the Bay attaining depths of 40 to 50 feet. This allows visualization of the entire Holocene section in San Francisco Bay.
3. The VHR instrument produces a source pulse containing energy at frequencies ranging from 3 to 10 kHz. Unique to this VHR system, return energy is captured with a separate hull-mounted, laterally-shielded receiver. The fidelity of this equipment proved to be superb in soft sediment areas with low bottom roughness.
4. Survey navigation will be controlled and recorded using the Pelagos Phrognav navigation system. Differential GPS survey methods will be used to obtain survey locations. GPS coordinates will be determined using Ashtec M-12 GPS receiver in conjunction with a land-based GPS receiver and radio link. The land-based systems data stream is merged with that of the roving GPS system and real-time differential GPS corrections are obtained. This navigation system will provide survey accuracy of a few feet.
5. Two shore-parallel survey tracks will be recorded around the western and southern perimeters of the West Beach Landfill Wetlands, with a total line length of about 24,000 feet.
6. Two shore-perpendicular survey lines will be recorded across the entrance of the Seaplane Lagoon with a total length of about 12,000 feet. Two shore-parallel survey lines will be recorded outside of the entrance onto Seaplane Lagoon with a total length of about 12,000 feet. The area of the Seaplane Lagoon will be surveyed on a grid pattern designed to include potential borehole locations in and near the Lagoon. Spacing of survey lines within the lagoon will be determined after essential survey targets have been established in discussions with the BEREC team, the Navy, and PRC. Dimensions of the Lagoon area are approximately 2000 x 2000 feet, thus a survey grid recorded on 400-foot centers would produce about 20,000 feet of lineal subbottom recordings. Total length of the project survey is thus approximately 68,000 feet.

7. This project is planned to obtain all surveys during single field program. In order that imaging results can be used to optimize overall project results field operations are designed with sufficient flexibility to allow the survey grid to be modified as needed to survey around obstructions, and to allow us to quickly design local surveys across areas of interest.
8. Because high confidence results are required in this study, acoustic imaging data will be gathered at two levels of resolution. Two separate acoustic receiving systems, will be simultaneously recorded. This strategy allows the direct comparison of overlapping shallow and intermediate depth surveys. The first receiving system is a Seistec inverted cone receiver, designed for extremely fine-scale imaging to a nominal depth of 40'. The inverted cone geometry provides good sound gathering, and helps to shield its receivers from environmental noise. The Seistec receiver will be recorded along with a multi-element ITI towed-cable receiver. The ITI receiver is capable of imaging to depth of 100 feet or more. The multi-element cable receiver provides good signal-to-noise reduction, and the cable's "hydrophone" receivers are the most sensitive available. The two channels of data will be recorded using an extremely fast Polaris Imaging *Eosin* digital recording system. The acoustic source is a Seistec magnetostrictive "boomer". The boomer has a bandwidth of 2-7.5 KHz. These frequencies can be expressed 7-75 cm wavelengths. Magnetostrictive "Boomers" have been in use for more than 20 years as shallow imaging sources. Their wide and high frequency range makes them a good choice for the proposed study.
9. Challenges for acquisition and interpretation of seismic reflection data from the shallow marine environment include the masking, attenuation and scattering of seismic energy by various kinds of environmental noise, entrained gas, and coarse lithologies. Interpretation can be difficult where submerged objects, out-of-line obstructions, and seismic multiples complicate the seismic records. Criteria have been developed for the objective evaluation of high resolution marine data.

6.0 ANALYTICAL METHODS

No chemical or physical property measurements will be performed in this procedure.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

Field data will be compiled with available borehole and historical data to produce maps of "original, historic and existing" topography. These "snapshots" will enhance our ability to establish portray relationships between the imaging and the borehole data. Lithological sections will be produced in conjunction with the borehole data, and these combined data will be interpreted to produce a spatial model of the geometry, lithology and origin of substrate features, and to infer substrate conditions.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUAL MANAGEMENT

No hazardous materials or wastes will be generated in this project. The lagoon and Bay waters that will contact equipment and protective clothing during the proposed studies is not regarded as contaminated, and therefore special decontamination of these materials is not required unless otherwise directed by the Site Health and Safety Officer.

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accord with the Quality Control Program Plan.

MICROELECTRODE MEASUREMENTS IN SEDIMENT CORE PORE WATERS

STANDARD OPERATING PROCEDURE 26.1

1.0 PURPOSE

This SOP describes the use of an innovative microelectrode to measure the concentrations of dissolved Fe, Mn, oxygen, and sulfide as a function of depth in a sediment column.

2.0 OBJECTIVES

The objectives of the procedure are as follows:

- Provide data on the presence of the above constituents in the sediment columns
- Profile the oxidation/reduction chemistry in the sediment that can be used to assess transformation reactions and concentrations of chemical constituents in the profile

3.0 REFERENCES

Brendel, P. J., and G. W. Luther, III. (1995). Development of a Gold Amalgam Voltammetric Microelectrode for the Determination Of Dissolved Fe, Mn, O₂, and S(-2) in Porewaters of Marine and Freshwater Sediments. Environ. Sci. Technol. 29(3) 751-761.

4.0 SPECIALIZED EQUIPMENT

The microelectrode used for this study will be borrowed from Dr. Luther, Department of Chemistry and Biochemistry, and College of Marine Studies, University of Delaware.

5.0 EXPERIMENTAL PROCEDURES

5.1 The procedures for the measurements using the electrode are described in the referenced paper; the paper is included in this SOP as Attachment 26.1-1

5.2 The microelectrode can potentially provide measurements on a frequency of several millimeters, and therefore data collection will be essentially continuous over the 20 cm core depth.

6.0 ANALYTICAL METHODS

6.1 The gold amalgam voltammetric microelectrode (Brendel and Luther, 1995) will be used to determine dissolved Fe(II), Mn(II), O_2 , and S(-II) concentrations in pore waters. The analyses of pore waters using the microelectrode are completely described in the referenced paper.

6.2 The microelectrode has been developed for the express purpose of measuring the specified constituents in sediment columns as a function of depth on a scale of millimeters. The attached paper specifically addresses topics such as maintenance, calibration, and conditioning of the electrode. Interferences as well as the effects of pH and other constituents are discussed in the paper. Similarly, the expected performance and the quality control measures to be used in the proposed measurements are also described.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

Examples of how the data are analyzed, interpreted and presented are described in the attached paper.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accordance with the Contractor Quality Control Program Plan (CQCPP) and the Standard Quality Procedure (SQP).

Attachment 26.1-1

**Brendel, P. J., and G. W. Luther, III.
Development of a Gold Amalgam Voltammetric Microelectrode for the
Determination of Dissolved Fe, Mn, O₂, and S(-2) in Porewaters
of Marine and Freshwater Sediments
Environ. Sci. Technol. 29(3) 751-761, 1995**

Development of a Gold Amalgam Voltammetric Microelectrode for the Determination of Dissolved Fe, Mn, O₂, and S(-II) in Porewaters of Marine and Freshwater Sediments

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A solid-state voltammetric gold amalgam microelectrode has been developed for the measurement of dissolved O₂, S(-II), Fe, and Mn in the porewaters of marine sediments. This electrode can provide more information at (sub)millimeter depth resolution on all of the major redox species found in the environment than membrane microelectrodes which usually can measure only one of these species per electrode. We describe the construction, standardization, analytical validation, and application of a microelectrode to marine sediments. The use of the microelectrode takes advantage of the fast scan voltammetric methods for simultaneous measurement of all redox species during one potential scan. Electrochemical conditioning of the solid-state microelectrode between voltage scans while deployed in waters and sediments allows for repeated use of the electrode. Finally, we demonstrate depth profiles at millimeter resolution for the redox species in a Delaware salt marsh. The profiles observed are consistent with the known biogeochemical cycling of the target redox species. In addition, we provide evidence for H₂O₂, iron(II) sulfide complexes, and iron(III) colloids or organic complexes in porewaters.

Introduction

Microelectrodes to determine the concentration of a single analyte have become an important tool for the elucidation of natural microbial and biogeochemical processes (1-11). These electrodes have been used to measure profiles of O₂, H₂S, pCO₂, N₂O, and pH in the environment. The profiles have allowed the calculation of O₂ fluxes (5-7) which are coupled to the production and consumption rates of organic matter by microorganisms. Membrane electrodes have also been used in combination for determining the O₂/H₂S interface of a microbiological community (11), for determining the photosynthetic rates in a microbial mat (8), and for determining deep water hydrothermal flow (4). Oxygen and N₂O microelectrodes have been used in combination for denitrification studies (10).

Many of the microelectrodes for environmental research (e.g., O₂, pCO₂, N₂O) depend on the flux of gas through a membrane for an analytical signal. The signal for amperometric type electrodes (O₂ and N₂O) is measured as a current at a fixed potential. Scanning voltage while measuring current in a normal voltammetric experiment has not been employed, which typically limits these electrodes to a single analyte each. Although much information has been gained with membrane electrodes, there are many nongaseous substances that cannot be detected with them, specifically dissolved Fe and Mn. These environmentally significant metals are released by microbial oxidation of organic matter with iron(III) oxides and Mn(III,IV) oxides as electron acceptors (12) and by reduction of their oxides with H₂S. Froelich et al. (12, Table 1) have shown that the use of available oxidants in the decomposition of organic matter will be determined by the oxidant yielding the greatest free energy change per mole of organic carbon oxidized. These reactions show that, as O₂ is depleted, concentrations of the other reduced species will increase depending on the availability of their oxidized form and reduced organic matter. Of particular interest is the reduction of iron(III) and manganese(III,IV) oxides and oxyhydroxides due to the high free energies resulting from the reactions of these minerals with organic matter. To date, iron profiles at a millimeter depth resolution have been accomplished by diffusion of dissolved iron into thin-layer gels (2) followed by proton-induced X-ray emission (PIXE) analysis. This method is limited to the availability of highly specialized equipment, and the gels used require significant equilibration times in the sediment. Ideally, a device capable of determining the concentration changes of several redox species at a time in these suboxic sedimentary environments would be of great use to a variety of disciplines involved with the study of natural biogeochemical processes.

We describe the use of a single working electrode to measure the key dissolved redox species [Fe, Mn, S(-II), and O₂] in the sedimentary environment by voltammetric methods. Our main objective is to understand more about the O₂/Mn, O₂/Fe, and Fe/H₂S interfaces. Studies to date using membrane microelectrodes have only focused on the oxic/anoxic interface, which is punctuated by nondetectable O₂ concentrations and the initial detection of H₂S

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PORE WATER CONSTITUENT MEASUREMENTS

STANDARD OPERATING PROCEDURE 26.2

1.0 PURPOSE

This procedure describes the collection of pore water samples from discrete depth intervals of saturated sediment cores. The methods used to analyze the pore water samples for anions, and trace and major metals are also described.

2.0 OBJECTIVES

The objectives of the procedures are as follows:

- Obtain pore water samples from defined depth intervals of sediment cores
- Provide analyses of anions, and major and trace metals
- Profile the constituents as a function of depth

3.0 REFERENCES

- Jahnke, R. A. 1988. A Simple, Reliable, and Inexpensive Pore-water Sampler. *Limnol. Oceanogr.* 33(3) 483-487.
- Esser B. K., Volpe A., Kenneally J. M., and Smith D. K. (1994). Preconcentration and Purification of Rare Earth Elements in Natural Waters using Silica-immobilized 8-hydroxyquinoline and a Supported Organophosphorus extractant. *Analytical Chemistry*, 66, 1736--1742.

4.0 SPECIALIZED EQUIPMENT

A device for extracting pore water from sediment cores will be constructed similar to that described in the by Jahnke (1988); this paper is included in this SOP as Attachment 26.2-1.

5.0 EXPERIMENTAL PROCEDURES

5.1 A 50 cm polymer sleeve (acrylic) used for sediment core collection will be predrilled at 5 cm intervals to provide sampling ports. This sleeve will be inserted into the sediment corer for sample collection.

5.2 After sample collection, the core in a sleeve will be capped and transported to LLNL for pore water and solid sampling. To maintain the chemical redox state in the sediment, the sediment

core will be transported and stored at 4°C. Pore water sampling and analyses will be conducted within 24 hours of sample collection.

5.3 The pore waters will be sampled by placing the 50 cm sleeve containing the undisturbed sediment core directly into a pressurized core pore water sampler (Jahnke, 1988).

5.4 Pore water samples are collected by placing gas tight syringe with 0.4 μ m filter into the sampling ports. As the core is pressurized, pore water samples from the corresponding depth segments are forced into the sample syringes. Approximately 10 discrete, depth-specific pore water samples will be collected for analyses.

5.5 Anion, total inorganic carbon, and dissolved organic carbon will be analyzed immediately after the pore waters are extracted from the pore water sampler. All transfers will be made in gas tight syringes.

5.6 For total metal analysis, aliquots of the pore waters will be placed in preacidified bottles for preservation. Metal analyses will be conducted within 15 days of samples collection.

6.0 ANALYTICAL METHODS

6.1 Anion Analysis: The anions of interest (Cl^- , F^- , NO_2^- , NO_3^- , SO_4^{2-} and PO_4^{3-}) will be analyzed using Waters Ion Chromatography method A-101 with Hewlett Packard 1090 liquid chromatograph, and using a Waters IC-Pak A column and borate gluconate eluent. Approximately 1 ml of sample is needed for these analyses.

6.2 Total Trace Metals (Cd, Cu, Cr, Ni, Pb, Zn): Trace metal concentrations in the pore waters are expected to be less than $\mu\text{g/L}$ (or parts per billion, ppb) concentrations. Therefore, analyses will be conducted in a class 100 clean room equipped with vented laminar flow hoods and a VG Plasma Quad PQ2 ICP-MS to collect accurate metal concentrations. Isotope spike additions for each trace metal of interest will be added to the filtered pore waters, followed by silica-immobilization 8-hydroxyquinoline purification treatment to remove the metals from the complex solution matrix which interferes with trace metal analyses (Esser et al., 1994). Detection limits of this techniques are on the order of 10^{-4} ppb.

6.3 Total Major Elements: Pore waters will be analyzed by ICP-AES (Applied Research Laboratory, Model 3560) for total dissolved Al, Ca, Fe, Na, Mg, Mn, and S, which have the respective detection limits: 0.06, 0.01, 0.02, 0.5, 0.01, 0.1, and 0.6 ppm, respectively.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

Analysis data for the constituents as a function of depth will be presented in tabular form and in graphical form.

8.0 HEALTH AND SAFETY

The performing organization's CQCPP and Health and Safety Plan will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accordance with the CQCP and SQP.

Attachment 26.2-1

Jahnke, R. A..

**A Simple, Reliable, and Inexpensive Pore-water Sampler.
Limnology and Oceanography 33(3) 483-487, 1988**

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A simple, reliable, and inexpensive pore-water sampler¹

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Abstract—A simple technique for extracting pore water from sediment cores has been developed. The overall concept of this procedure is to gently pressurize an intact sediment subcore, forcing the pore fluids to be expelled through sampling ports located at specific depths in the core barrel wall. Although this technique does not necessarily improve the integrity of the sample obtained for most solutes, it is much easier to perform than previously reported procedures. Because this technique does not require the sediments to be sectioned into sampling intervals before pore-water extraction, it is rapid and eliminates the need for walk-in cold vans, specialized equipment such as sediment squeezers, high-speed centrifuges and gimbals, and glove bags (for sampling anoxic sediments).

Studies of pore-water geochemistry have been widely used to identify and evaluate the importance of reactions occurring in marine sediments (Froelich et al. 1979; Emerson et al. 1980). In the past, pore waters have been recovered by diffusion into a "peeper" (Hesslein 1976), by suction into a "harpoon" sampler (Sayles et al. 1976), and by separation of interstitial waters from sediment cores either by centrifugation (Emerson et al. 1980) or squeezing (Bender et al. 1987; Kehil and Goldhaber 1973; Presley et al. 1967). Each of these methods has advantages and limitations. Although peepers are simple and have the potential to recover samples free of temperature, pressure, and

oxidation artifacts, the need for long equilibration times has limited their use. Harpoon samplers also can recover pore waters free of sampling artifacts but have limited depth resolution and are more expensive to construct and operate.

Despite the limitations imposed by the occurrence of pressure-related artifacts (Murray et al. 1980; Jahnke et al. 1982; Froelich et al. 1983; Toole et al. 1984), extraction of pore waters from sediment cores is still the most widely used sampling technique, especially at water depths <1,000 m. Regardless of which separation technique is used, the extraction of pore water in this manner is a laborious procedure requiring the sediment core to be sectioned at the appropriate sampling intervals. The method is further encumbered by the requirement that all manipulations must be performed at in situ temperatures and in an inert atmosphere (in anoxic sediments) to avoid temperature and oxidation artifacts.

I describe here a simple device by which pore-water samples can be obtained at 1-cm or greater depth intervals from sediment cores on board ship. The device is inexpensive to build and eliminates the need for a walk-in cold van, centrifuge and gimbals, glove bags, or specialized components such as custom-built squeezers. The simplicity and speed of pore-water extraction increases the number of cores that can be processed and the pore-water analyses that can be completed at sea.

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SEDIMENT BULK AND MINERALOGICAL ANALYSES

STANDARD OPERATING PROCEDURE 26.3

1.0 PURPOSE

This procedure describes the sample preparation and analyses of sediment solids. The analysis procedures include determination of the mineralogy, morphology, and bulk metals concentrations. This information will be used to assess the samples that are most representative of the sediment column.

2.0 OBJECTIVES

The objectives of the procedures are as follows:

- Provide analyses of bulk (total) metals concentrations for comparison with data obtained by PRC
- Provide data on mineralogy and morphology of sediment materials to determine the types of solids in samples
- Compare sediment properties to determine samples that are most representative of the sediment profile for subsequent x-ray absorption spectroscopy

3.0 REFERENCES

Flegal A. R. Cutter L. S., and Martin J. H. (1981). A Study of the Chemistry of Marine Sediments and Wastewater Sludge, Calif. State Water Res. Control Board.

4.0 SPECIALIZED EQUIPMENT

Equipment to be used is described the Analytical Methods section

5.0 EXPERIMENTAL PROCEDURES

5.1 To prevent oxidation of the sediments, the 2 m cores will be sectioned as a function of depth in a nitrogen environment. The sediment core will be segmented for analyses in 20 cm increments, providing 10 discrete samples. If necessary, sections will be rinsed in oxygen-free water containing a sodium chloride (NaCl) concentration similar to the site waters to remove any dissolved metals in the pore waters.

5.2 The rinsed sections will be immediately freeze dried. In the absence of water, no chemical reactions take place. The dry solids will be dry sieved to determine sediment size fractions. The individual size fractions will be dry grounded into a fine powder for subsequent analysis.

6.0 ANALYTICAL METHODS

6.1 Bulk mineralogy will be analyzed on the solid powders using powder x-ray diffraction with a Scintag x-ray diffractometer XPH-105 using Cu Ka radiation. The samples will be analyzed by continuous step scan from 2° to 70° 2-theta with a step size of 0.02° using 1 by 2 mm entrance and 0.3 by 0.2 mm exit slits.

6.2 Sediment morphology of the powders will be determined, if necessary, by analysis with a Hitachi S-800 SEM with a Kevex 8000 energy dispersive spectrometer EDS and a beryllium window. This technology affords the morphology and micro-chemical analysis of the sediment samples.

6.3 The bulk inorganic composition represented by total metals and sulfur concentrations in the solid phases will be determined by ICP- AES (Applied Research Laboratory, Model 3560) following aqua regia digestions of the solid powders (Flegal et al., 1981).

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

The measurements of bulk composition will be compared to data from PRC to determine the samples that appear to be most representative of lagoon sediments. These data as well as the mineralogy and morphology information will then be used to select samples that are of interest because of their common occurrence in sediment or higher concentrations of metals of concern. These samples (not less than 4 but not more than 8) will be analyzed by x-ray absorption spectroscopy.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accordance with the CQCPP and SQP.

SEDIMENT METAL SPECIATION ANALYSES

STANDARD OPERATING PROCEDURE 26.4

1.0 PURPOSE

This procedure describes the analysis of selected sediment samples by x-ray absorption spectroscopy to determine metal speciation in sediments.

2.0 OBJECTIVES

The objective of the procedure is to provide information of the speciation of the metals in sediment.

3.0 REFERENCES

- Brown, G.E., Jr., Calas, G., Waychunas, G.A., and Petiau, J. (1988) X-ray Absorption Spectroscopy and its Applications in Mineralogy and Geochemistry. *Spectroscopic Methods in Mineralogy and Geology*, F. Hawthorne, ed., Reviews in Mineralogy 18, Washington, DC: Mineral. Soc. of Amer., pp. 431-512.
- Brown, G.E., Jr. (1990) Spectroscopic Studies of Chemisorption Reaction Mechanisms at Oxide-water Interfaces. *Mineral-Water Interface Geochemistry*, M.F. Hochella, Jr. and A.F. White, eds., Reviews in Mineralogy 23, Washington, DC: Mineral. Soc. Amer., 309-363.
- Carroll S., Phillips B., O'Day P., Waychunas G., and Piechowski M. (1994) Environmental Applications of EXAFS: Zinc Structure in Acid Mine Drainage Sediments. GSA Abstracts with Programs A-289.
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Knauss K. and Wolery T. J. (1986) Dependence of Albite Dissolution Kinetics on pH and time at 25 and 70°C. *Geochimica Cosmochimica Acta*, 50, 2481-2497.

4.0 SPECIALIZED EQUIPMENT

Equipment to be used in the procedure is described in the Analytical Methods section

5.0 EXPERIMENTAL PROCEDURES

5.1 The trace metals Cd, Cu, Cr, Hg, Ni, Pb, and Zn and their redox state in the solid phase will be determined using synchrotron-based x-ray absorption spectroscopy (XAS). To determine the chemical reactions that control metal distribution, the mineral phases must be identified that are associated with the metal species and the metal ion coordination, bonding, and oxidation state. XAS is one of the few techniques that can provide quantitative information about the local molecular structure of environmentally-important elements at mineral-solution interfaces (Brown et al., 1988; Brown 1990; Manceau and Charlet, 1992; O'Day et al., 1994a,b; Waychunas et al., 1993). Carroll and co-workers have demonstrated the feasibility of using this technique on metal ions in complicated acid mine drainage sediments.

5.2 Approximately 4 to 8 samples collected and prepared according to the SOP 26.3 will be analyzed. The samples will be selected for XAS analysis based on their representativeness as determined in SOP 26.3 and with concurrence of the Navy.

6.0 ANALYTICAL METHODS

6.1 Absorption spectra for dried, untreated solid powders will be measured at the Stanford Synchrotron Radiation Laboratory (SSRL) on beamlines 4-3 or 10-2 at cryogenic temperature ($\approx 10^4$ K) under dedicated conditions (3 GeV, 40-90 mA). High iron samples will be diluted by 50% with B(OH)₃ to enhance signal statistics.

6.2 The dry powder samples will be loaded into 1 mm thick Al holders and sealed with Mylar film. Cd (26.5 to 27.8 keV), Cu (8.9 to 9.6 keV), Cr (5.9 to 6.5 keV), Ni (8.3 to 0.9 keV), Zn (9.4 to 10.7 keV) K-edge and Pb (13.0 to 14.1 keV) L(III)-edge and their extended spectra will be collected using an unfocused Si(220) or Si(111) monochromator crystal and a 13-element Ge fluorescence array detector.

6.3 Solid standard compounds will be diluted with inert B(OH)₃ to produce approximately 30% transmission of the incoming beam. Model spectra will be collected in transmission-mode using N₂, Ar, and Kr-filled ion chambers (optimized for beam energy). Energy calibration will be obtained by simultaneous collection of a metal foil or standard compound for the element of interest. Harmonic rejection will be achieved by detuning the incoming beam by 30 to 50% of maximum intensity.

6.4 Depending on metal concentration, 3-30 scans will be collected and averaged for each sample.

6.5 Data reduction and analysis will be performed with the EXAFSPAK programs (G. George, SSRL). For spectra analysis, reference phase-shift and amplitude functions will be generated using FEFF6 (Rhee, 1993) based on atomic clusters from known crystal structures.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

This information on metal speciation will be used with geochemical models and data from the pore water analyses to estimate chemical behavior in undisturbed sediments. Also, the presence of zero-valent metals (in the metallic form) will also be useful for comparison with the lead-210 and other sediment dating procedures to assess the despositional history of the sites.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accordance with the CQCPP and SQP.

LEACHING FROM DISTURBED SEDIMENTS

STANDARD OPERATING PROCEDURE 26.5

1.0 PURPOSE

This procedure is to simulate leachate solutions from Seaplane Lagoon sediments that have been dredged and placed on land where they are exposed to air and rainwater.

2.0 OBJECTIVES

The objective of the procedure are as follows:

- Evaluate the trace metal constituent concentrations as a function of tie that may be expected to leach from dredged sediment soils
- Assess changes in sediment speciation after extended leaching with aerated water
-

3.0 REFERENCES

Knauss, K., and T.J. Wolery. 1986. Dependence of Albite Dissolution Kinetics on pH and Time at 25° and 70°C. *Geochemical Cosmochimica Acta*, 50, 2481-2497.

4.0 SPECIALIZED EQUIPMENT

5.0 EXPERIMENTAL PROCEDURES

5.1 The following experiment will be conducted on sediments from the Seaplane Lagoon to determine the rate at which metal contaminants are released into the more mobile aqueous phase. Leaching experiments will be conducted on two sediment samples considered to be of most interest based on discussions among the Co-Principal Investigator, lead Principal Investigator, and the Navy.

5.2 The experiments will be performed in flow-through reactors at room temperature (Knauss and Wolery, 1986). In these experiments, the rate of metal leached is proportional to the change in concentration between the input and output solutions; the input leaching solution will be analyzed periodical too.

5.3 The initial sediment solid phase will be well mixed, but not ground to a uniform size fraction. All rates will be normalized with respect to total mass of sediment and possibly the initial

concentration of metal contaminant. The duration of the leaching experiments will be 3 months and the following sample schedule will be followed: days 1, 2, 3, 5, 8, 11, 14, 21, 28, 35, 42, 49, 56, 63, 70, 80, and 90. The solution pH and total metal will be analyzed according to the procedures described in SOP 26.2.

5.4 These experiments are designed to measure the rate at which metals in the subsurface are leached into the aqueous phase when they are removed from their oxygen poor environment to an oxygen rich environment. The leaching solution will consist of distilled and deionized water equilibrated with atmospheric carbon dioxide; this composition simulates rainwater.

5.5 At the completion of these experiments, the solids will be freeze-dried and ground for XAS (see SOP 26.4 above) to determine if the metal speciation in the solids phase changed during the leaching experiment. This information is important, because it is highly likely that metals that are stable in anoxic sediments will dissolve and then sorb on or react with other solid phases in oxic sediments. If this is the case, then the long-term availability of the metals may be significantly limited, because the metals will be associated with solid phases in both environments. These experiments will provide leaching rates that can be applied to remediation scenarios that involve the dredging of Seaplane Lagoon sediments and their subsequent disposal on land.

6.0 ANALYTICAL METHODS

The composition of the leachate and the speciation of metals in the leached sediment will be analyzed as described in SOP 26.2 and 26.4, respectively.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

The data from the leaching experiments will be presented in tabular and graphical formats. The speciation of the resulting leached sediments also will be compared to the speciation of the original sediment materials, and interpreted based on the composition of the leachate.

8.0 HEALTH AND SAFETY

The performing organizations health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accord with the Quality Control Program Plan.

PORE WATER TOXICITY TEST

STANDARD OPERATING PROCEDURE 27.1

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the steps followed in the assessment of pore water toxicity at the Seaplane Lagoon and the West Beach Landfill Wetlands. This procedure is applicable to BERC and subcontractor personnel involved in collection of environmental samples and performance of specific tests required under this study.

2.0 OBJECTIVES

The objective of the test conducted under this study is to evaluate toxicity of the pore water fraction of sediment from the Seaplane Lagoon and the West Beach Landfill Wetlands.

3.0 REFERENCES

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- American Society for Testing and Materials (ASTM). 1989. *Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of four species of Saltwater Bivalve Molluscs*. Method E 724-89. American Society for Testing and Materials. Philadelphia, PA.
- Anderson, B.S., J.W. Hunt, M. Hester, and B.M. Phillips. 1995. Assessment of Sediment Toxicity at the Sediment-Water Interface. In Press in *Techniques in Aquatic Toxicity*. SRC Press. Boca Raton, Florida.
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- Anderson, S.L., and J.P. Knezovich. 1995. Potential Positive Interferences in Sediment Toxicity Tests. *A Briefing Report to the In Bay Studies Work Group of Interagency Long Term Management Strategy (LTMS) Committee*. September 1995.
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4.0 SPECIALIZED EQUIPMENT AND MATERIALS

Specialized equipment to be used in the toxicity tests include a Sorval RC-2 centrifuge for pore water extraction, Ponar dredger for sediment collection, water baths, 20-ml glass scintillation vials, and a Nitex mesh, Leitz and reichert compound microscopes, Oriental dissecting microscopes, a Perkin-Elmer spectrophotometer, several Orion meters and glassware.

5.0 EXPERIMENTAL PROCEDURES

The pore water tests are conducted by exposing test organisms to pore water extracted from sediment samples using the following procedures:

A. General Procedures

1. Two species, an amphipod and an echinoderm, will be used in this study.
2. Sediment samples are stored at 4°-8° C for no more than 24 hours prior to pore water extraction.
3. Pore water for testing is obtained using SOP 25.3.

B. The Echinoderm 72-Hour Development Test

All echinoderm tests follow EPQA methods for water column testing (EPA/600/R-95/136) with the following exceptions:

1. The tests are conducted using either purple sea urchins (*Strongylocentrotus purpuratus*) or sand dollar (*Dendraster exentricus*) embryos, at a salinity of 34 ppt \pm 2. If unavailable, a bivalve test will be conducted (see C below).
2. Organisms are held in aquarium with clean filtered seawater at approximately 8°C prior to spawning. Adults are spawned by injecting 1-2 milliliters of 0.5M potassium chloride into their oral cavity.
3. Sperm is collected by dry spawning (S. Anderson *et. al.*, 1990). Tests are run in 20-ml glass scintillation vials with a 20-ml test volume of pore water.
4. The test is terminated by adding 1 ml of 5% gluteraldehyde solution to each of the vials after 72 hours.
5. Percent normal development is determined at the end of the test.

C. The Bivalve 48-Hour Embryo Development Test

1. The bivalve developmental test will be used as an alternate to the echinoderm test, depending on availability of the preferred test species.

2. The 48 hour bivalve test will be performed using either mussel embryos, *Mytilus edulis* or at a salinity of 30 ppt ± 2 . Adults are spawned in water baths heated to 20°C with clean, filtered seawater.
3. At the onset of spawning, each individual is separated into a beaker containing clean filtered seawater at test temperature.
4. Tests are run in 20ml glass scintillation vials with a 20-ml test volume of pore water. This reduces the head space in the vial and minimizes any artifacts of oxidation.
5. The test is terminated by adding 1ml of 5% gluteraldehyde solution to each of the vials after 48 hours.
6. Percent normal development is determined at the end of the test.

D. Alternative: Amphipod 10-Day Survival Test

1. Pore water toxicity tests using the amphipod *Eohaustorius estuarius* are conducted using a modification of Swartz *et al.* (1985).
2. Tests are run in 200-ml acid washed plastic cups with 100-ml of test solution and five amphipods per cup.
3. The test chambers are covered with loosely fitted caps to reduce evaporation.
4. Tests are conducted in pore water with both a seawater and site-water control at 16°C without the addition of sediment. Previous studies by the principal investigators have demonstrated excellent survival in 100-ml solutions without sediment (Anderson *et al.*, 1995).
5. Amphipod survival is monitored daily and dead amphipods are removed.
6. Salinity and temperature are monitored daily, and pH, percent oxygen, and ammonia are measured at the beginning and end of each test. The standard endpoint for this test is percent survival.

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories approved by the Navy. analytical methods used are listed in Table SAP-3, and are referenced in the EPA publication SW 846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

Work conducted under this study will comply with the Health and Safety Plan (HSP) prepared for this project; the HSP contain routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under the SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

SEDIMENT WATER INTERFACE CORE TEST (SWIC)

STANDARD OPERATING PROCEDURE 27.2

1.0 PURPOSE

This procedure describes the steps followed in the characterization of sediment toxicity at Seaplane Lagoon and the West Beach Landfill Wetlands. Specifically, the distribution of toxic responses at the two site using intact surface sediment toxicity tests will be characterized. This procedure is applicable to BERC and subcontractor personnel involved in collection of environmental samples and performance of specific test required under this study.

2.0 OBJECTIVES

Another objective of the tests conducted under this study is to characterize how sediment toxicity varies with depth in Seaplane Lagoon. The objectives of the test it to assess the toxicity of sediment to test organisms.

3.0 REFERENCES

Anderson, B.S., J.W. Hunt, M. Hester, and B.M. Phillips. 1995. Assessment of Sediment toxicity at the Sediment-Water Interface. In Press In Techniques in Aquatic Toxicity. CRC Press. Boca Raton, Florida.

Anderson, S.L. E. Hoffman, D. Steward, and J. Harte. 1990. Ambient Toxicity Characterization of San Francisco Bay and Adjacent Wetlands Ecosystems. *LBL-29579*,

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United States Environmental Protection Agency (USEPA). 1995. *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine Estuarine Organisms*. EPA-600-4-91-003. July, 1994.

4.0 SPECIALIZED EQUIPMENT

Specialized equipment to be used in the SWIC test are shown in presented in Section 5.3.2 of the Work Plan.

5.0 PROCEDURES

A. General Procedures

1. Sediment water interface corer (SWIC) tests are conducted by placing test organisms in contact with whole sediment cores fitted with mesh screen inserts. An amphipod and an echinoderm species will be used in this study.
2. Procedures for collecting intact cores are reviewed in SOP 25-1.
3. All sediment core samples are stored at 4°C without freezing and with no head-space prior to testing, to reduce the risk of artifacts. Twenty-four hours prior to testing, the initial site-water is extracted from each core and replaced with 250 ml of 0.45 μm filtered site-water. Inserts are then placed inside the corers and the corers are allowed to equilibrate at test temperature.

B. Echinoderm 72-Hour Development Test

1. The sediment water interface echinoderm toxicity tests are conducted using a modification of B. Anderson et al., (1995) and the EPA protocol for water column testing (EPA/600/R-95/136).
2. Echinoderms are spawned as described previously (See SOP 27-1). Approximately 600 embryos are inoculated into each core insert. Inserts have a mesh screen size of 50 μm to prevent embryos from falling onto sediment. Since the embryos are negatively buoyant, they will settle on the Nitex screen, which is at the sediment water interface.
3. At the end of the exposure, the inserts are removed from the core and rinsed in clean filtered seawater. The embryos are washed through a funnel into a 20 ml. glass scintillation vial and fixed with a 5% final concentration gluteraldehyde. Percent normal development is determined at the end of the test.

C. Alternative: Bivalve 48-Hour Embryo Development Test

1. The sediment water interface bivalve toxicity tests are conducted using a modification of B. Anderson *et al.*, (1995) and the ASTM protocol for water column testing (E-724-89).
2. Bivalves are spawned as described previously (See SOP 27-1).
3. Approximately 600 embryos are inoculated into each core insert. Inserts have a mesh screen size of 50 μ m to prevent embryos from falling onto the sediment. Since the embryos are negatively buoyant, they will settle on the Nitex screen, which is at the sediment water interface.
4. At the end of the exposure, the inserts are removed from the core and rinsed in clean filtered seawater. The embryos are washed through a funnel into a 20 ml glass scintillation vial and fixed with a 5% final concentration glutaraldehyde. Percent normal development is determined at the end of the test.

D. Amphipod 10-Day Survival Test

Amphipod toxicity tests are conducted as described previously (See SOP 27-1) with the following modifications:

1. Five amphipods are placed into each corer insert. Inserts have a mesh screen size of 50 μ m to prevent amphipods from burrowing into sediment.
2. At the end of the exposure period (10 days) the inserts are removed from the corers and rinsed in clean filtered seawater.
3. The amphipods are washed through into a 5 cm x 5 cm x 5 cm container filled with clean seawater.
4. The number of live amphipods is counted and percent survival is the accepted endpoint.

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories acceptable to the Navy. Analytical methods use are listed in Table 5-2 and are referenced in the EPA publications SW 846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

During the implementation of this SAP, safety and health considerations will be included. A separate Health and Safety Plan (HSP) has been prepared for this project which contain routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

TOXICITY IDENTIFICATION EVALUATIONS

STANDARD OPERATING PROCEDURES 27.3

1.0 PURPOSE

This Standard Operation Procedure (SOP) describes the toxicity identification evaluation (TIE) approach which employs a series of chemical fractionations and manipulations of pore water that are subsequently used to identify the compound or class of compounds that are responsible for the observed toxic effects in the pore water samples from Seaplane Lagoon and West Beach Landfill Wetlands. This procedure is applicable to BERC and subcontractor personnel involved in collection of environmental samples and performance of specific test under this study.

2.0 OBJECTIVES

The objectives of this task are to identify the classes and identifies of toxicants that are responsible for pore water toxicity at the Seaplane Lagoon and the West Beach Landfill Wetlands. The work is focused on identifying toxicants in pore water from surface sediments at both sites .

This task will be closely coordinated with evaluation of survival and development toxicity (SOP 27.1). The results of these coordinated tasks will provide the identity of chemical classes and individual contaminants at the Seaplane Lagoon and at the West Beach Landfill Wetlands that are responsible for sediment toxicity.

3.0 REFERENCES

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4.0 Specialized Equipment

No special equipment is required for conducting this SOP.

5.0 Procedures

A. General Procedures

1. This task is closely coordinated with evaluation of acute and developmental toxicity test. Toxicity identification evaluations (TIEs) will be used to identify used the toxicant(s) that are responsible for the observed toxicity in Seaplane Lagoon and West Beach Landfill Wetlands sediments.
2. The TIE approach described here consists of a combination of sample manipulation techniques, chemical separation, and quantitation, that are subsequently used to identify the compound(s) or class of compounds that are responsible for the observed toxic effects. This approach is in accordance with guidelines set fourth or under development by the U.S. Environmental Protection Agency (Ankley *et al.*, 1991). An overview of this approach is presented and discussed in Section 5.3.3 of the Workplan.
3. Samples in which pore water is demonstrated to be toxic (See SOP 27-1) will be subjected to a set of tiered treatments and analyses. These steps will focus on resolving the relative contributions of metals and organic pore water fractions to sediment toxicity.
4. Subsequent analyses will focus on the identification of individual causative agents. The units used to report the results of this work are EC-, LC-50s, Toxic units (TU) and microgram per liter ($\mu\text{g/L}$).

B. Assessment of Toxicity Related to Ammonia and Sulfides in Pore Water

1. Initial assessments of pore water will include the measurement of sulfides and ammonia, which may be present at levels that are toxic to organisms used to evaluate sediment toxicity. Because both of these compounds occur naturally in marine and estuarine sediments, it is necessary to evaluate their possible contribution to sediment toxicity before effects attributed to xenobiotic contaminants are assessed.
2. Total sulfide concentrations will be determined in pore water using a modification of the methylene-blue method (Knezovich *et al.*, 1996).
3. Concentrations of hydrogen sulfide, which accounts for the toxicity of total sulfide, will be calculated according to standard methods (APHA) 1985). Hydrogen sulfide

will be identified as contributing to toxicity if its concentration exceeds the lowest observable effect concentration (LOEC) that has been determined for the test species (Knezovich *et al.*, 1996). Hydrogen sulfide values in excess of the LC- or EC-50 values will also be reported as toxic units (TU). Hydrogen sulfide that is present at toxic concentrations will be removed from pore water via gentle aeration for 2 hours prior to subsequent toxicity testing.

4. Total ammonia concentrations will be determined in pore water using an ion-specific electrode. Ammonia will be identified as contributing to toxicity if its concentration exceeds the LC- or EC-50 concentration that has been determined for the test species (S.R.Hansen & Assoc., 1995). Ammonia values in excess of the LC- or EC-50 values will also be reported as toxic units (TU). Ammonia that is present at toxic concentrations will be removed from pore water via passage through zeolite prior to toxicity testing.

C. Assessment of Toxicity Related to Metals in Pore Water

1. A tiered approach will be used to evaluate the potential contribution of heavy metals to sediment toxicity (See **Section 5.3.3 of the Work Plan**).
2. This approach is being used to gain immediate information on the likelihood of metal-induced toxicity but cannot be used exclusively because toxicity might not be diminished due to the presence of other toxicants.

D. Removal of Bioavailable Metals via Chelation

1. Sequestering agents that complex heavy metals and render them unavailable to the test organisms will be used to assess the contribution of these potential toxicants to the observed toxic effects.
2. Ethylenediaminetetraacetic acid (EDTA) will be added to pore water to reduce the bioavailability of copper, cadmium, mercury, zinc, lead and nickel. Sodium thiosulfate (STS) will be added to pore water to reduce the bioavailability of silver.
3. Pore waters amended with these chelators will be evaluated for toxicity.
4. A diminution of toxicity will indicate that heavy metals are contributing to toxicity. Such results will be followed by an analysis of individual metals in pore water to ascertain the toxic element(s) (see below). If toxicity is not diminished, then other toxicants are assumed to be responsible for some or all of the impact.
5. For pore water samples that result in complete toxicity (e.g. 100% abnormality), the results of chelation studies may be inconclusive. This can occur because chelation of bioavailable metals will not diminish toxicity if other toxicants are present in concentrations that are greater than or equal to two toxic units. In these cases, the analyses of metals in pore water will be used to ascertain their contribution to toxicity.

E. Determination of Dissolved Metal Concentrations in Pore Water

1. In cases where metal toxicity is suspected removal of toxicity via chelation, and/or 100% toxicity), individual metal concentrations will be determined. Dissolved

metals (i.e., passed through a 0.45 μm membrane filter) will be quantified by atomic absorption spectrophotometry. Concentrations of individual metals will be compared to existing toxicity data bases to calculate toxic units.

F. Assessment of Toxicity Related to Organic Compounds

1. The assessment of toxicity that can be attributed to organic compounds will be addressed according to the approach presented in Figure 3, which has been adapted from the work of Burkhard *et al.* (1991) and Ankley *et al.*, (1991a).
2. Organic toxicants present in pore water will be fractionated using solid-phase extraction (SPE) techniques. If toxicity is reduced by the solid phase treatment, recovered compounds are then subjected to fractionation by high-performance liquid chromatography (HPLC).
3. The resulting HPLC fractions are then subjected to gas chromatography/mass spectrometry (GC/MS) analyses or high-performance liquid chromatography/mass spectrometry (HPLC/MS) for the determination of polar and non-polar toxicants, respectively. The purpose of the SPE fractionation is to crudely isolate the toxicants from the majority of the other components. This is followed by HPLC fractionation to more precisely isolate the toxicants from components that would interfere with the GC/MS analyses.
4. Following GC/MS analyses, a list of potential toxicants is developed. This list is subsequently refined by a process of elimination using both concentration estimates and toxicological information, the ultimate goal being a list of identified toxicants.

G. Removal of Organic Toxicants

Non-polar compounds

1. Pore water will be initially passed through C-18 solid phase extraction columns at ambient pH (e.g. 7 to 8) to remove neutral, non-polar compounds. This process will remove compounds such as pesticides (e.g. DDT), polyaromatic compounds (e.g., fluoranthene), and polychlorinated biphenyls (PCBs). Pore water that has passed through the C-18 treatment will be evaluated for toxicity. Removal of toxicity will indicate the presence of neutral, non-polar toxicants.

Acidic, non-polar compounds

1. Pore water that is adjusted to pH 6 will be passed through C-18 solid phase extraction columns. The pore water will subsequently be adjusted back to ambient pH prior to toxicity testing. An increase in the removal of toxicity as a result of this treatment will indicate the presence of acidic, non-polar compounds (e.g. phenols).

Basic Non-polar compounds

1. Pore water that is adjusted to pH 9 will be passed through C-18 solid phase extraction columns. The pore water will subsequently be adjusted back to ambient pH prior to toxicity testing. An increase in the removal of toxicity as a result of this treatment will indicate the presence of basic, non-polar compounds (e.g., aromatic amines).

Identification of polar organic compounds

1. Pore water samples that have been subjected to C-18 treatment and metal chelation but retain toxicity will be evaluated for the presence of polar organic toxicants. Because many of these compounds (e.g., surfactants) are not amenable to analysis by gas chromatography, they will be fractionated by HPLC and analyzed by HPLC/MS, as necessary.

Toxicant Confirmation

1. Spiking of pore water and/or sediment elutriates with identified chemicals will be performed to confirm the presence of suspected toxicants. For samples in which toxicity is less than 100%, suspect toxicants will be added directly. A concomitant increase in toxicity will serve to confirm the toxicants contribution.
2. Toxicity observed as a result of this approach will provide strong evidence for the action of the toxicant in the field sample. These approaches are appropriate because toxicants frequently behave in an independent fashion (e.g., their toxicity is not additive; Ankley *et al.*, 1991a).

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories acceptable to the Navy. Analytical methods use are listed in Table SAP-3 and are referenced in the EPA publication SW-846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

During the implementation of this SAP, safety and health considerations will be included. A separate Health and Safety Plan (HSP) has been prepared for this project which contain routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

ACID VOLATILE SULFIDES AND SIMULTANEOUSLY EXTRACTED METALS

STANDARD OPERATING PROCEDURE 27.4

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the Acid Volatile Sulfides and Simultaneously Extracted Metals (AVS/SEM) which is a good estimator of metal bioavailability and toxicity in the sediment samples from Seaplane Lagoon and Wet Beach Landfill Wetlands. This procedure is applicable to BERC and subcontractor personnel involved in collection of environmental samples and performance of specific test required under this study.

2.0 OBJECTIVES

The objective of this task are to establish the AVS/SEM ratio and to use this ratio to assess the potential for metal-related toxicity in intact sediments.

3.0 REFERENCES

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4.0 SPECIALIZED EQUIPMENT

No specialized equipment are required for this test.

5.0 PROCEDURES

A. General Procedures

1. The bioavailability of metals in bulk surficial sediments will be evaluated by the measurement of acid volatile sulfides (AVS) and simultaneously extracted metals (SEM). AVS has emerged as a good estimator of metal bioavailability and toxicity in marine and freshwater sediments because sulfide controls the concentrations of divalent metals (e.g. Ni^{2+} , Pb^{2+} , Cd^{2+} , Cu^{2+} , Hg^{2+} , Zn^{2+}) in pore water through the reaction sulfide to form insoluble metal precipitates. As a result of this process, AVS also controls metal availability and toxicity (Allen *et al.* 1993; DiToro *et al.*, 1992).
2. Sediments that have relatively high concentrations of metals and correspondingly high or excess AVS do not exhibit metal-related toxicity (Ankley *et al.*, 1991b; DiToro *et al.*, 1992). Sediments that are highly oxidized and have low AVS may exhibit toxicity even though the concentrations of heavy metals are relatively low.
3. The relationship between sediment oxidation and AVS is critical for understanding the potential for toxicity in sediments that are likely to become oxidized via remedial activities such as dredging. This is important because sediment aeration is likely to result in lower AVS and the subsequent liberation of toxic heavy metals (Zhuang *et al.*, 1994).
4. Surficial sediments obtained from Seaplane Lagoon and the West Beach Landfill Wetlands will be subjected to AVS and SEM analyses using the methods of Allen *et al.*, (1993).
5. Single aliquots (approximately 10 to 20 g) of wet sediment obtained from the top 2 cm of sediment cores will be treated with a solution of hydrochloride acid.
6. Evolved sulfides will be trapped in solutions of sodium hydroxide, which removes the hydrogen sulfide gas as sulfide ion. Total sulfides will subsequently be quantified using a modification of the methylene blue method (APHA, 1985).
7. Following the recovery of AVS from sediment samples, the resulting hydrochloride acid solution will be analyzed for extracted metals. Copper, zinc, lead, nickel, and cadmium will be measured by atomic absorption spectrophotometer.
8. The ratio of SEM to AVS will then be used to assess the potential for metal-related toxicity in intact sediments.
9. An SEM/AVS ratio less than one will indicate that metals are not bioavailable and hence not toxic. An SEM/AVS ratio that is greater than one indicates that metals are bioavailable and potentially toxic.
10. Samples that exhibit ratios greater than one will be subjected to further evaluations to determine the presence of metal-related toxicity (See SOP 27.3).

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories acceptable to the Navy. Analytical methods use are listed in Table 5-2 and are referenced in the EPA publications SW 846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

During the implementation of this SAP, safety and health considerations will be included, a separate Health and Safety Plan (HSP) has been prepared for this project which contain routine safety guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

BIOAVAILABILITY/BIOACCUMULATION BY THE BIVALVE

STANDARD OPERATING PROCEDURES 28.1

1.0 PURPOSE

This Standard Operation Procedure (SOP) describes bioavailability/bioaccumulation test of organic chemicals by the bivalve, *Macoma nasuta* exposed to the sediment samples from Seaplane Lagoon, Wet Beach Landfill Wetlands and other locations. This procedure is applicable to BEREC and subcontractor personnel involved in collection of environmental samples and performance of specific test required under this study.

2.0 OBJECTIVES

The general objective of bioavailability evaluation is to quantify the uptake of organic chemicals into organisms, total concentration of organic chemicals will also be measured to assess the bioavailable fraction. Specific objectives of the bioavailability tests include determining whether chemicals in sediment at Seaplane Lagoon and West Beach Landfill Wetlands are (1) bioavailable to deposit-feeding invertebrates, (2) at which sites they are most bioavailable, (3) which chemicals exhibit the greatest bioavailability; and (4) how bioaccumulation of contaminants from these sediments compare with other locations within San Francisco Bay.

3.0 REFERENCES

EPA/COE. 1994. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (Draft). Prepared by the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers. EPA-823-B-94-002.

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4.0 Specialized Equipment

No specialized equipment are required for this test.

5.0 Experimental Procedures

A. General Procedures

1. Bioaccumulation by the bivalve *Macoma nasuta* is a standardized and widely used procedure to test the bioavailability of sediment-bound contaminants. Dredged material is typically tested by this procedure to determine acceptable disposal options (EPA/COE. 1994), and the EPA has promulgated standard procedures for conducting these tests (Lee et al., 1989).
2. The sediment of interest is placed in beakers, and bivalves are added to the sediment. After 28 days the animals are sacrificed, and tissue residue levels quantified. Data are reported as toxicant concentrations in tissue as ppb.
3. These tests will be conducted using *Macoma nasuta* collected from a relatively uncontaminated area of Bodega Bay. Three tests in replicate will be conducted for each sediment: the tests consist of four Seaplane Lagoon and three West Beach Landfill Wetlands sediments, one reference sediment from mid-San Francisco Bay, and one control sediment from *Macoma nasuta*'s original collection site. After the completion of each test series, tissues will be analyzed for PAH, PCB, and DDT.
4. A 28-day exposure period is the standard protocol for the *Macoma species* test, and is sufficient time for most compounds to reach a steady state tissue concentration. It is possible, however, that steady state will not be attained for DDT or some PCBs in this time period. Other studies (Lee et al., 1994) have found that one-third to one-half of DDT steady state is attained by *Macoma nasuta* in 28 days

The data may be adjusted to account for this underestimating. The only other foreseeable conditions that would limit use of the *Macoma species* bioaccumulation test is if the sediments are too toxic for survival of the test organisms. *Macoma species* are relative insensitive to many pollutants and we do not anticipate a problem, but nevertheless, premature mortality of the test organism would, in itself, be significant information.

5. Chemical body burdens attained by bivalves held in NAS Alameda sediments will be evaluated by comparison to several other data sets. Animals from the Bodega Bay site will represent relatively unimpacted conditions, and the increase at NAS Alameda, relative to this control, will be quantified.

6. NAS Alameda chemical body burdens will be compared to animals held in sediments from the three mid-San Francisco Bay sites. Body burdens will also be compared to data sets available from other projects.
7. While *Macoma species* are not consumed by humans, demersal fishes that prey on *Macoma species* could be, and it is likely that fish tissue residue levels would be as great or greater than in their prey. Thus, while FDA action levels were not developed for non-commercially exploited species, both EPA and the U.S. Army Corps of Engineers advocate their use in the manner proposed here (EPA/COE, 1994).

Resident bivalves

1. In order to confirm the *Macoma species* bioaccumulation data, resident bivalves will be collected and analyzed, if available. *Macoma species* are resident in San Francisco Bay, and may be present in the Seaplane Lagoon. PRC (1994) reports presence of the bivalves *Gemma gemma*, *Macoma senhousia*, and *Theora fragilis*. *Macoma senhousia* is large enough to provide adequate tissue for analysis and will be used if *Macoma species* are not found.
2. The resident bivalves will be collected by grab sampler, and processed in the same manner as the *Macoma species* in the laboratory exposures. Field tissue residue data will be compared to the laboratory bioaccumulation data, and to other San Francisco Bay sites and FDA standards as described above.

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories acceptable to the Navy. Analytical methods use are listed in Table 5-2 and are referenced in the EPA publication SW-846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

During the implementation of this SAP, safety and health considerations will be included. A separate Health and Safety Plan (HSP) has been prepared for this project which contain routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

DIGESTIVE FLUID EXTRACTION

STANDARD OPERATING PROCEDURE 28.2

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a procedure for simulating bioavailability/bioremediation of organics exposed to the sediment samples from Seaplane Lagoon and Wet Beach Landfill Wetlands. This procedure is applicable to BERC and subcontractor personnel involved in collection of environmental samples and performance of specific test required under this study.

2.0 OBJECTIVES

The broad objective of bioavailability evaluation is to quantify the simulated extraction of chemicals from contaminated sediments, rather than basing management decisions on chemical concentrations that may be chemically measurable but biologically unavailable. Specific objectives of the bioavailability tests include determining (1) whether chemicals in sediment at Seaplane Lagoon and West Beach Landfill Wetlands are bioavailable to deposit-feeding invertebrates, (2) at which sites chemicals are most bioavailable (3) and how bioaccumulation of contaminants from these sediments compare with other locations within San Francisco Bay. Bioavailability will be evaluated by extraction of contaminants by digestive fluids from a marine worm.

3.0 REFERENCES

EPA/COE, 1994, Evaluation of dredged material proposed for discharge in waters of the U.S.-Testing Manual (Draft). Prepared by the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers. EPA-823-B-94-002.

Lee, H., B.L. Boese, J. Pelletier, M. Winsor, D.T. Specht, R.C. Randall. 1989. Guidance Manual: Bedded Sediment Bioaccumulation Tests. Prepared by the U.S. Environmental Protection Agency. EPA/600/x-89/30.

Lee *et al.* (13 other authors). 1994. Ecological risk assessment of the Marine Sediments at the United Hechathorn Superfund Site. U.S. Environmental Protection Agency, ERL-N-269.

Mayer, L.Z. Chen, R. Findlay, J. Fang, S. Sampson, L. Self, P. Jumars, C. Quetel, and O. Donard. (submitted). Bioavailability of sedimentary contaminants subject to deposit-feeder digestion. Environmental Science and Technology.

PRC. 1994. Naval Air Station Alameda, Alameda, California: Ecological Assessment. Prepared for the U.S. Navy by PRC Environmental Management, San Francisco.

4.0 SPECIALIZED EQUIPMENT

No specialized equipment are required for this tests.

5.0 EXPERIMENTAL PROCEDURES

1. Bioavailability and/or bioaccumulation will also be assessed by a novel method of extraction using the digestive fluid from a marine worm, *Arenicola brasiliensis*. Digestive solubilization will be reproduced *in vitro* using the digestive fluid extracted from sacrificed worms.
2. Contaminants solubilized by this procedure will be quantified, and are taken as, or the very least correlated with, the bioavailable contaminant fraction.
3. The sediment concentrations of PAHs, PCBs, and DDP will also be quantified (ug/kg), as well as the fraction of the contaminant solubilized by digestive fluid (ug/L). The solubilized contaminants will be regarded as potentially bioavailable, representing the maximum concentration of organic chemicals that can be extracted from sediment as that sediment passes through the gut of a deposit-feeding organism.

Sediment Core Samples

1. Sediment cores will be collected from locations near outfalls in the Seaplane Lagoon. These cores will be used for bioavailability testing using sediment segments from surface sediments and from depths of 1 meter and 2 meters. Tests will also be conducted using surficial sediment samples collected from three locations in the permanently flooded areas of the West Beach Landfill Wetlands. Additionally, a total of three reference samples will also be obtained from three central Bay sites, roughly off Alameda, Yerba Buena and Tiburon.
2. Ancillary data including TOC, water content and grain size will also be measured from the sediment samples.
3. The deposit-feeding polychaete *Arenicola brasiliensis* will be collected from intertidal areas of the central California coast, and digestive fluid extracted.
4. The sediment samples will be incubated in the digestive field for 4 hours after which the suspension will be centrifuged and the supernatant recovered for organic analyses by GC or GC/MS.

Extraction Test

1. The method is based on the assumptions that ingestion of contaminated food is an important route of contaminant uptake and that solubilization of contaminants during digestion is a necessary prerequisite for bioaccumulation. These assumptions are likely to be most valid for hydrophobic and persistent contaminants

with a high bioaccumulation potential, and it is compounds such as these on which we will focus (i.e. PAH, PCB, DDT).

2. The Digestive Fluid Extraction is a new method based on a published procedure in the literature (Mayer et al., in press). It was originally developed with funding by the Office of Naval Research, and has subsequently been used to evaluate sediments in southern California, San Francisco Bay, New England and Europe.

6.0 ANALYTICAL METHODS

All samples collected for this project will be analyzed by laboratories acceptable to the Navy. Analytical methods use are listed in Table 5-2 and are referenced in the EPA publications SW- 846, Test Methods for Evaluating Solid Waste. Appropriate test methods will be used whenever EPA methods do not exist.

7.0 HEALTH AND SAFETY

During the implementation of this SAP, safety and health considerations will be included. A separate Health and Safety Plan (HSP) has been prepared for this project which contains routine safety procedures, guidelines for field personnel, and emergency procedures.

8.0 RESIDUALS MANAGEMENT

Any waste or excess samples must be disposed according to applicable local, state and federal environmental laws and regulations. The laboratory performing the analyses is responsible for the disposal of hazardous waste or residual materials.

9.0 RECORDS

Field and laboratory documentation will constitute the records required under this SAP. Properly completed field notebooks, chain-of-custody forms and laboratory documentation will be kept and made part of the SAP records.

LEAD-210 PROFILE IN SEDIMENT

STANDARD OPERATING PROCEDURE 29.1

1.0 PURPOSE

This procedure describes the sampling and analyses used to provide a profile of lead-210 isotope concentrations in Seaplane Lagoon sediments. This procedure also describes the analyses of the cesium-137 isotope profile that also may be determined.

2.0 OBJECTIVES

The objective of this procedure is to profile the concentration of the lead-210 isotope as a function of depth in Seaplane Lagoon sediment. Information on the use of the profile information is presented in Section 5.5.1 of the Work Plan.

3.0 REFERENCES

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4.0 SPECIALIZED EQUIPMENT

Equipment required is described below in the Experimental Procedures and Analytical Methods sections.

5.0 EXPERIMENTAL PROCEDURES

5.1 Samples for the analysis of lead-210 in the Seaplane Lagoon sedimentary profile will be collected from the sediment core at intervals of every 20 cm using 1 cm increments. The remaining core will be reserved for subsequent analysis if needed.

5.2 An expected core 300 cm long will provide initially 15 samples for analysis. Since only a few grams of sediment are required, duplicates within a given depth are easily accomplished. Samples for analysis will also include blanks and NIST standards.

6.0 ANALYTICAL METHODS

6.1 Radioisotopes are very useful in tagging sediments; through the natural isotopic decay, the age of the sediments can be determined. The main focus will be on lead-210, while other radioisotopes will be explored if other contaminants are present. The analyses will be conducted by Dr. Brad Esser of the Isotope Sciences Division, LLNL, who has measured similar lead-210 profiles in San Francisco Bay.

6.2 Lead-210 will be determined by alpha-counting its Polonium-210 (^{210}Po) granddaughter and assuming secular equilibrium that is achieved after two weeks of storage. The analytical technique we will use has been in extensive use by many laboratories (Smith and Hamilton, 1984; Benoit and Hemond, 1988).

6.3 Approximately one gram of sediment sample will be leached sequentially in hot nitric and then hot hydrochloric acid. A weighed aliquot of ^{209}Po or ^{208}Po spike solution will be added and chemically equilibrated during the hydrochloric acid leach. After each leach procedure, the leachate will be separated from residual solids by centrifuging, and evaporated slowly to dryness. The final leachate evaporation residue will be taken up in 0.5 N hydrochloric acid with ascorbic acid added to complex Fe (which interferes with Po plating).

6.4 Polonium will be separated from solution by spontaneous plating onto a silver planchet at 60°C over a period of about four hours. Plated Po activities (^{210}Po at 5.304 MeV, ^{208}Po at 5.115 MeV, ^{209}Po at 4.882 MeV) will be determined by alpha energy spectrometry using partially-depleted silicon surface barrier detectors. Sample ^{210}Po activity will be determined from the measured activity ratio of sample ^{210}Po to spike ^{209}Po or ^{208}Po . All counting will be done at LLNL. LLNL Po spikes are calibrated against NIST-traceable ^{210}Pb solutions. The use of a calibrated spike allows quantitative determination of ^{210}Po activity without having to precisely characterize chemical yield, plating efficiency, plating thickness, and counting geometry.

6.5 Cesium-137 (^{137}Cs) and Radium-226 (^{226}Ra) activities will be determined by gamma energy spectrometry using solid-state Ge detectors. Large volume (10-20 g) sediment samples will be sealed in cans and aged for at least two weeks to allow Radon-222 (^{222}Rn , 3.82 days) and its short-lived daughter ^{214}Pb (26.8 min.) to grow into secular equilibrium with ^{226}Ra . Cans will be placed on planar detectors and counted for 1-5 days; the technique is nondestructive. ^{137}Cs will be determined from its 661.6 keV gamma decay, and ^{226}Ra will be determined from the 353.0 keV gamma decay of ^{214}Pb . The gamma energy spectral data will be reduced using a LLNL computer code which makes corrections for self-adsorption, detector efficiency, and spectral interferences.

6.6 This technique will provide estimates of sediment age (years before present) as a function of sediment depth using a sediment core from the Seaplane Lagoon. Actual lead-210 measurements are presented as activities (Bq/g of sediment).

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

The lead-210 and cesium-137 concentration will be presented as a function of depth. As discussed in section 5.6.1, several interpretations of the data may be necessary depending on site history. It will be initially assumed that excess lead-210 in the sedimentary profile comes from the atmospheric deposition of lead-210 decayed from radon-222 and reflecting the uranium content of San Francisco Bay Area near-surface rocks and soils. Lead-210 has a half life of 22.3 years and provides a good tool for looking at sedimentary processes over the last 10 to 200 years (one half to ten half-lives).

As discussed in Section 5.5.1, if sediment samples at a depth demonstrate an elevated level of lead-210, those samples will be subjected to gamma particle counting to confirm the presence of radium-226. Since gamma counting will also measure the activity of cesium-137, the concentrations of this isotope will also be determined. These data will complement other data obtained in the study.

Another initial assumption that is utilized in interpreting sedimentary profiles is that the sediment is not mixed, and this is likely at the Seaplane Lagoon given the contamination levels that ought to have limited macrofauna bioturbation. The actual profiles of redox sensitive chemical species such as oxygen, iron(II), and sulfide measured as part of geochemistry studies will indicate if this is reasonable over short time scales of days at the Seaplane Lagoon. The lead-210 profile will indicate if surface sediment mixing is happening on longer time frames. If substantial surface sediment mixing is found, an added parameter of a mixed depth for the sediment profile as has been used in previous investigations.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accordance with the CQCPP and SQP 4.2.

MEASUREMENT OF LAGOON SEDIMENT PROPERTIES

STANDARD OPERATING PROCEDURES 29.2

1.0 PURPOSE

This procedure describes the sediment sampling and measurements that will be conducted on sediment core segments from the Seaplane Lagoon. The measurements will be conducted according to ASTM standards.

2.0 OBJECTIVES

The objectives of this procedure are to obtain values of density, organic content, void ratio and compressibility for sediment segments at depth to 3 meters in the Seaplane Lagoon. These data will be used to evaluate the water flow within sediments.

3.0 REFERENCES

ASTM Standard D 854-92, Standard Test Method for Specific Gravity of Soils, ASTM Standard D 2435-90, Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM Standard D-2974-87, Standard Test Methods for Moisture, Ash, Organic Matter of PEAT and Other Organic Soils.

4.0 SPECIALIZED EQUIPMENT

Equipment to be used is described in the ASTM standards. A consolidometer to be used is located in the UCB Graduate Geotechnical Laboratory.

5.0 EXPERIMENTAL PROCEDURES

1. The sediment core will be extruded from the sampling liners, and segmented to provide a sample for measurements. Consolidation measurements will be conducted on 2.85 inch diameter core segment of approximately 1 inch thickness. The segments will be taken from the center of the 4 inch sediment core segment to minimize any effects of edge compaction due to sampling with the sleeve.
2. Because of the probable soft nature of some sediments compared to the soil samples usually used in the consolidation measurements, the segmenting and testing will be conducted under the direction of the Co-Principal Investigator, Dr. Nicholas Sitar.

3. Measurements will be conducted in the Graduate Geotechnical Laboratory of UCB's Geotechnical Engineering Department.

6.0 ANALYTICAL METHODS

Analyses will be performed according to ASTM standards; these methods are included in this SOP Attachment 29.2.1.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

Procedures for calculating the density, organic content, void ratio and compressibility are described in the respective ASTM methods (Attachment 29.20-1)

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be compiled within all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for the purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accord with the Quality Control Program Plan.

Attachment 29.2-1

**ASTM Standard D 854-92, Standard Test Method for
Specific Gravity of Soils**

**ASTM Standard D 2435-90, Standard Test Method for
One-Dimensional Consolidation Properties of Soils**

**ASTM Standard D 2974-87, Standard Test Methods for
Moisture Ash, Organic Matter of Peat and other Organic Soils**

Standard Test Method for Specific Gravity of Soils¹

This standard is issued under the fixed designation D 854; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

¹ NOTE—Editorial changes were made throughout in September 1993

1. Scope

1.1 This test method covers the determination of the specific gravity of soils that pass the 4.75-mm (No. 4) sieve, by means of a pycnometer. When the soil contains particles larger than the 4.75-mm sieve, Test Method C 127 shall be used for the material retained on the 4.75-mm sieve and this test method shall be used for the material passing the 4.75-mm sieve.

1.1.1 Two procedures for performing the specific gravity are provided as follows:

1.1.1.1 *Method A*—Procedure for Oven-Dry Specimens, described in 9.1.

1.1.1.2 *Method B*—Procedure for Moist Specimens, described in 9.2. The procedure to be used shall be specified by the requesting authority. For specimens of organic soils and highly plastic, fine-grained soils, Procedure B shall be the preferred method.

1.2 When the specific gravity value is to be used in calculations in connection with the hydrometer portion of Test Method D 422, it is intended that the specific gravity test be made on that portion of the sample which passes the 2.00-mm (No. 10) sieve.

1.3 The values stated in acceptable metric units are to be regarded as standard.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate²

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials²

D 422 Test Method for Particle-Size Analysis of Soils³

D 653 Terminology Relating to Soil, Rock, and Contained Fluids³

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)³

¹ This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

Current edition approved Nov. 15, 1992. Published January 1993. Originally published as D 854 - 45. Last previous edition D 854 - 91.

² Annual Book of ASTM Standards, Vol 04.02.

³ Annual Book of ASTM Standards, Vol 04.08.

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing³

E 1 Specification for ASTM Thermometers⁴

E 11 Specification for Wire-Cloth Sieves for Testing Purposes⁵

E 12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases⁶

2.2 AASHTO Standards:⁷

AASHTO Test Method T100

3. Terminology

3.1 All definitions are in accordance with Terminology D 653 and E 12.

3.2 *Description of Term Specific to This Standard:*

3.2.1 *specific gravity*—the ratio of the mass of a unit volume of a material at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

4. Significance and Use

4.1 The specific gravity of a soil is used in calculating phase relationships of soils (that is, the relative volumes of solids to water and air in a given volume of soil).

4.2 The term solid particles is typically assumed to mean naturally occurring mineral particles that are not readily soluble in water. Therefore, the specific gravity of materials containing extraneous matter (such as cement, lime, and the like), water-soluble matter (such as sodium chloride), and soils containing matter with a specific gravity less than one, typically require special treatment or a qualified definition of their specific gravity.

5. Apparatus

5.1 *Pycnometer*—The pycnometer shall be one of the following:

5.1.1 *Volumetric Flask*, having a capacity of at least 100 mL.

5.1.2 *Stoppered Bottle*, having a capacity of at least 50 mL. The stopper shall be of the same material, and shall permit the emission of air and surplus water when it is put in place.

⁴ Annual Book of ASTM Standards, Vol 14.03.

⁵ Annual Book of ASTM Standards, Vol 14.02.

⁶ Annual Book of ASTM Standards, Vol 15.05.

⁷ Available from American Association of State Highway and Transportation Officials, 444 N Capital St., NW, Washington, DC 20001.

Standard Test Method for One-Dimensional Consolidation Properties of Soils¹

This standard is issued under the fixed designation D 2435; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers procedures for determining the magnitude and rate of consolidation of soil when it is restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. Two alternative procedures are provided as follows:

1.1.1 *Test Method A*—This test method is performed with constant load increment duration of 24 h, or multiples thereof. Time-deformation readings are required on a minimum of two load increments.

1.1.2 *Test Method B*—Time-deformation readings are required on all load increments. Successive load increments are applied after 100 % primary consolidation is reached, or at constant time increments as described in Test Method A.

NOTE 1—The determination of the rate and magnitude of consolidation of soil when it is subjected to controlled-strain loading is covered by Test Method D 4186.

1.2 This test method is most commonly performed on undisturbed samples of fine grained soils naturally sedimented in water, however, the basic test procedure is applicable, as well, to specimens of compacted soils and undisturbed samples of soils formed by other processes such as weathering or chemical alteration. Evaluation techniques specified in this test method are generally applicable to soils naturally sedimented in water. Tests performed on other soils such as compacted and residual (weathered or chemically altered) soils may require special evaluation techniques.

1.3 It shall be the responsibility of the agency requesting this test to specify the magnitude and sequence of each load increment, including the location of a rebound cycle, if required, and, for Test Method A, the load increments for which time-deformation readings are desired.

NOTE 2—Time-deformation readings are required to determine the time for completion of primary consolidation and for evaluating the coefficient of consolidation, c_v . Since c_v varies with stress level and load increment (loading or unloading), the load increments with timed readings must be selected with specific reference to the individual project. Alternatively, the requesting agency may specify Test Method B wherein the time-deformation readings are taken on all load increments.

1.4 The values stated in SI units are to be regarded as the standard. The values stated in inch-pound units are approximate and given for guidance only. Reporting of test results

in units other than SI shall not be regarded as nonconformance with this test method.

1.4.1 In the engineering profession it is customary practice to use, interchangeably, units representing both mass and force, unless dynamic calculations ($F = Ma$) are involved. This implicitly combines two separate systems of units, that is, the absolute system and the gravimetric system. It is scientifically undesirable to combine two separate systems within a single standard. This test method has been written using SI units; however, inch-pound conversions are given in the gravimetric system, where the pound (lbf) represents a unit of force (weight). The use of balances or scales recording pounds of mass (lbm), or the recording of density in lb/ft³ should not be regarded as nonconformance with this test method.

1.5 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 422 Method for Particle-Size Analysis of Soils²
- D 653 Terminology Relating to Soil and Rock²
- D 854 Test Method for Specific Gravity of Soils²
- D 1587 Practice For Thin-Walled Tube Sampling of Soils²
- D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures²
- D 2487 Classification of Soils for Engineering Purposes³
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)³
- D 3550 Practice for Ring-Lined Barrel Sampling of Soils²
- D 4186 Test Method for One-Dimensional Consolidation Properties of Soils Using Controlled-Strain Loading²
- D 4220 Practice for Preserving and Transporting Soil Samples²
- D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils²
- D 4452 Methods for X-Ray Radiography of Soil Samples²
- D 4546 Test Methods for One-Dimensional Swell or Settlement Potential of Cohesive Soils³

3. Terminology

3.1 *Definitions*—The definitions of terms used in this test method shall be in accordance with Terminology D 653.

¹ This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of subcommittee D18.05 on Structural Properties of Soil.

Current edition approved June 29, 1990. Published November 1990. Originally published as D 2435 - 65T. Last previous edition D 2435 - 80.

² Annual Book of ASTM Standards, Vol 04.08.

³ Annual Book of ASTM Standards, Vol 04.08.



Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils¹

This standard is issued under the fixed designation D 2974; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover the measurement of moisture content, ash content, and organic matter in peats and other organic soils, such as organic clays, silts, and mucks.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Test Methods

2.1 **Test Method A**—Moisture is determined by drying a peat or organic soil sample at 105°C. The moisture content is expressed either as a percent of the oven dry mass or of the as-received mass.

2.2 **Test Method B**—This is an alternative moisture method which removes the total moisture in two steps: (1) evaporation of moisture in air at room temperature (air-drying), and (2) the subsequent oven drying of the air-dried sample at 105°C. This method provides a more stable sample, the air-dried sample, when tests for nitrogen, pH, cation exchange, and the like are to be made.

2.3 **Test Methods C and D**—Ash content of a peat or organic soil sample is determined by igniting the oven-dried sample from the moisture content determination in a muffle furnace at 440°C (Method C) or 750°C (Method D). The substance remaining after ignition is the ash. The ash content is expressed as a percentage of the mass of the oven-dried sample.

2.4 Organic matter is determined by subtracting percent ash content from one hundred.

3. Apparatus

3.1 **Oven**, capable of being regulated to a constant temperature of 105 ± 5°C.

NOTE—The temperature of 105°C is quite critical for organic soils. The oven should be checked for "hot spots" to avoid possible ignition of the specimen.

3.2 **Muffle Furnace**, capable of producing constant temperatures of 440°C and 750°C.

¹ These test methods are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.18 on Peats and Related Materials.

Current edition approved May 29, 1987. Published July 1987. Originally published as D 2974 - 71. Last previous edition D 2974 - 84.

3.3 **Evaporating Dishes**, of high silica or porcelain of not less than 100-mL capacity.

3.4 **Blender**, high-speed.

3.5 **Aluminum Foil**, heavy-duty.

3.6 **Porcelain Pan, Spoons**, and equipment of the like.

3.7 **Desiccator**.

4. Preparation of Sample

4.1 Place a representative field sample on a square rubber sheet, oil cloth, or equivalent material. Reduce the sample to the quantity required by quartering and place in a moisture-proof container. Work rapidly to prevent moisture loss or perform the operation in a room with a high humidity.

MOISTURE CONTENT

5. Test Method A

5.1 Record to the nearest 0.01 g the mass of a high silica or porcelain evaporating dish fitted with a heavy-duty aluminum foil cover. The dish shall have a capacity of not less than 100 mL.

5.2 Mix thoroughly the representative sample and place a test specimen of at least 50 g in the container described in 5.1. Crush soft lumps with a spoon or spatula. The thickness of peat in the container should not exceed 3 cm.

5.3 Cover immediately with the aluminum foil cover and record the mass to the nearest 0.01 g.

5.4 Dry uncovered for at least 16 h at 105°C or until there is no change in mass of the sample after further drying periods in excess of 1 h. Remove from the oven, cover tightly, cool in a desiccator, and record the mass.

6. Test Method A Calculation

6.1 Calculate the moisture content as follows:

$$\text{Moisture Content, \%} = [(A - B) \times 100]/A$$

where:

A = mass of the as-received test specimen, g, and

B = mass of the oven-dried specimen, g.

6.1.1 This calculation is used primarily for agriculture, forestry, energy, and horticultural purposes and the result should be referred to as the moisture content as a percentage of as-received or total mass.

6.2 An alternative calculation is as follows:

$$\text{Moisture Content, \%} = [(A - B) \times 100]/B$$

where:

A = as-received test specimen, g, and

B = mass of the oven-dried specimen, g.

FINGERPRINTING PAHS, PCBS, HYDROCARBONS, AND HYDROCARBON TRACERS

STANDARD OPERATING PROCEDURE 30.1

1.0 PURPOSE

These procedures will measure the concentrations of individual PAH constituents, PCB congeners, total petroleum hydrocarbon (TPH) fractions as well as specific hydrocarbon tracers in sediment core segments.

2.0 OBJECTIVES

The objective of this procedure will be to measure the concentrations of the specified analytes as a function of depth in lagoon sediments. As discussed in Section 5.6.1 of the Work Plan, these data will be used to estimate the transformation rates of PCBs and PAHs in the sediment; the hydrocarbon data will be used to estimate the rate of change of hydrocarbons in the sediment.

3.0 REFERENCES

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4.0 SPECIALIZED EQUIPMENT

No specialized equipment will be required for this procedure, although expertise in the use of gas chromatography will be required to optimize instrument performance for identifying specific PCB congeners.

5.0 EXPERIMENTAL PROCEDURES

5.1 As for the lead-210 analyses (SOP 29.1), the analysis of organics in the Lagoon sedimentary profile will be done initially using 1 cm increments samples from an interval of every 20 cm with the remaining part of the reserved for subsequent analysis. These data will determine if finer resolution is needed. An expected core 300 cm long will provide initially 15 samples for analysis. Because only 20 grams of sediment are required for each analysis, duplicates within a given depth can be accomplished.

6.0 ANALYTICAL METHODS

Analysis will be performed using methods described in SW 846. PAH constituents will be analyzed by EPA Method 8100, and PCBs will be analyzed by EPA Method 8080A (Table SAP-3). Modifications in temperature programming or longer chromatographic columns may be necessary for improved analyses of PAHs or PCB congeners.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

The data reported for the Seaplane Lagoon sediments by PRC indicates that there should be sufficient contaminants present for detection and quantification of PCB congeners to quantify transformations over time periods of 20 to 50 years. Examples of how the data may be analyzed and interpreted are discussed in Section 5.6.1 of the Work Plan.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accordance with the CQCPP and SQP 4.2.

INTRINSIC PRODUCTION OF METHANE IN ANAEROBIC LAGOON SEDIMENTS

STANDARD OPERATING PROCEDURE 30.2

1.0 PURPOSE

The purpose of this procedure is to measure the rates and amounts of methane generated in Seaplane Lagoon sediments. The measurements will be conducted on sediment core segments from the Seaplane Lagoon and the data from this procedure are then site specific and are not to be used for other sites where the depositional history and constituents are expected to be different.

2.0 OBJECTIVES

The objectives of the SOP are to provide information on the intrinsic rates and amounts of methane that may be expected to be generated from undisturbed Seaplane Lagoon sediments. This information will be used to assess remedial options, including the methane that would be generated should a sediment cap be installed. This information will also be useful to assess the activity of the microbial community that is able to dechlorinate PCBs.

3.0 REFERENCES

Simbert, R.M., and N.R. Krieg. 1994 Phenotypic characterization. In: Methods for General and Molecular Bacteriology. Gerhardt, P., R.G.E. Murray, W. A. Wood, N. R. Krieg (eds), pp 631-632. American Society for Microbiology. Washington D.C.

4.0 SPECIALIZED EQUIPMENT

Anaerobic incubation chambers and glove boxes for maintaining anoxic conditions will be used.

5.0 EXPERIMENTAL PROCEDURES

A 1 m lagoon sediment core will be segmented into 10 cm portions under anoxic conditions and placed in anaerobic incubation chambers equipped with rubber sampling ports.

On a weekly basis, gas samples will be removed and analyzed by gas chromatography.

The weekly analysis schedule will be maintained for at least 8 weeks, and until the amount of methane produced in one week is less than 1% of the total methane produced.

6.0 ANALYTICAL METHODS

Methane production will be analyzed by gas chromatography according to procedures of Simbert and Krieg (1994).

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

Data for the amount of methane produced per unit time from different depth segments will be presented in tabular form and in graphical plots.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accord with the CQCPP and SQP 4.2.

INTRINSIC TRANSFORMATION OF PAHs AND PCBs IN ANAEROBIC SEDIMENTS

STANDARD OPERATING PROCEDURE 30.3

1.0 PURPOSE

The following procedure is provided as an empirical approach to assess the intrinsic rates of remediation of PAHs and PCBs in undisturbed, anaerobic sediments from the Seaplane Lagoon and in the Landfill Wetlands. The procedure is designed to simulate intrinsic sediment conditions. The data from conduct of this procedure is specific to the site and strata from which the sediments were collected.

2.0 OBJECTIVES

The objectives of the procedure are to:

- Provide data to estimate the rate of transformation of PAHs and PCBs in anaerobic, undisturbed sediments
- Measure conditions in the anaerobic sediments that can be used to assess the potential for comparable transformation rates in other site locations

3.0 REFERENCES

See SOP 29.1 for referencesw describing PAH and PCB transformation processes.

4.0 SPECIALIZED EQUIPMENT

Equipment required for the proposed procedures consists of 2 L flasks equipped with a system for purging the flask headspace with a synthetic gas mixture to maintain anoxic conditions.

5.0 EXPERIMENTAL PROCEDURES

1. Sediment core segments of approximately 15 cm length (4 inch diameter core, approximately 2.4 kg) from the 0.5 to 1.0 meter depth will be extruded from the coring sleeve in a glove box under anoxic conditions and transferred to 2 L flasks. The core materials will be thoroughly mixed so as to achieve a maximally homogeneous sample for sampling. Four reactors will be prepared for each of the two sites, each topped with 1 L of deaerated site water above the sediment surface after settling. The reactors will be maintained under anoxic conditions and the headspace continually purged with a synthetic gas mixture of nitrogen/carbon dioxide and in proportions of 85:10:5.

2. After mixing for 48 hours to stabilize the sediment/water system and maximize the homogeneity of chemical distribution, three 25 gm sediment samples will be collected from each stirred reactor and analyzed for PAHs, PCBs, total metals, organic carbon content, sulfate, phosphate, nitrate, ammonia and total sulfides; the redox potential and conductivity of the slurried mixture will also be measured.
3. The analytical data will be reviewed for agreement among reactors, and the variance in the concentration data calculated for the PAH and PCB components. These analyses will provide a baseline of chemical concentrations and conditions for evaluating the initial characteristics of what is expected to be an anaerobic, methanogenic condition in sediment. The data on the concentration will also be used to determine what losses of constituents may be practically measured based on the initial concentrations present and the variance in the data.
4. If initial PAH and PCB concentrations are of a similar magnitude as the concentration variances such that a 50% concentration loss in PAH or PCB cannot be measured, a possible modification in the procedure, such as addition of PCBs or PAHs to increase concentrations, will be discussed with the Principal Investigator, Quality Control Program Manager, and Navy.
5. The unstirred reactors will be maintained in a 15°C temperature bath for six months to simulate quiescent sediment conditions.
6. The redox potential and pH of water above the sediment water will be monitored weekly to assess the stability of the system.
7. After three months, two reactors will again be thoroughly stirred to obtain a maximally homogeneous mixture of chemicals, and three 25 gm samples will be collected for analyses of the same analytes as above.
8. After an additional 3 months (or a total of six months), the remaining two reactors will be thoroughly stirred and samples collected for analyses.
9. Stirring of the sediment mixture is conducted to provide a optimally homogeneous media for sampling with the intent of minimizing the concentration variance due to sampling heterogeneity. It is assumed that the organic loading and other constituents of the sediment will restore the sediments to steady state conditions.
10. Data from the chemical characterization tasks will be reviewed to assess the robustness of the system toward any changes due to microbial activity in the sediments.

6.0 ANALYTICAL METHODS

Three samples will be collected from each reactor at the designated times for analyses. It is expected that three samples will provide a practical measure of the variance and average of PAH and PCB concentrations for assessing losses due to transformation reactions. The analytical procedures for the organic and inorganic constituents are listed in Table SAP-3. The reporting limits goals are also listed in the table, but may not be achievable due to expected matrix interferences.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accord with the CQCPP and SQP 4.2.

CONSTRAINTS ON TRANSFORMATION OF PAHs AND PCBs IN SEDIMENTS

STANDARD OPERATING PROCEDURES 30.4

1.0 PURPOSE

The following procedure is designed as an empirical approach to evaluate the intrinsic remediation of PAHs and PCBs in sediments where oxygen, nitrate, sulfate, and carbon dioxide/methanogenesis are the dominant electron acceptors facilitating oxidative transformation of the title chemicals in the Seaplane Lagoon sediments. The proposed procedure simulates conditions expected in discrete upper layers of sediment where the specific electron acceptors control the sediment chemistry. The data from these procedures is likely a function of variables that are not specifically measured, and therefore is specific to the site and strata from which the sediments were collected.

2.0 OBJECTIVES

The objectives of the procedure are to:

- Provide data to estimate the rates of transformation of PAHs and PCBs in sediments where oxygen, nitrate, sulfate and carbon dioxide, respectively are the electron acceptors
- Measure conditions in sediments that can be used to assess the potential for comparable transformation rates in the environment

3.0 REFERENCES

4.0 SPECIALIZED EQUIPMENT

Equipment required for the proposed procedures consists of 4L Erlenmeyer flasks equipped with a system for addition of reagents.

5.0 EXPERIMENTAL PROCEDURES

1. Sediment core segments of approximately 15 cm length (4 inch diameter core, approximately 2.4 kg) from the surface sediment will be extruded from the coring sleeve under anoxic conditions and transferred to 4L flasks. Each reactor will be topped with 1L of deaerated site water above the sediment surface after settling. The core materials will be thoroughly and continuously mixed so as to achieve a maximally homogeneous sample reactant distribution and for sampling. Two reactors will be prepared for each of the four reagent systems. Reagents will be added daily and

the headspace continually purged with an nitrogen/carbon dioxide/hydrogen ratio of 85:10:5. mixture.

2. To provide a higher concentration of chemicals for study, 0.1 gm each of selected PAHs and a PCB mixture will be added to each flask: the resulting concentrations are expected to be approximately 50 mg/kg (or 50 ppm). Additionally, one PAH will be ¹⁴C-radiolabeled to track metabolism of the PAH to carbon dioxide, soluble products, or sediment -bound material. The proposed PAHs for study are phenanthrene and chrysene (3- and 4-member ring PAHs, respectively). These chemicals will be slowly added to stirred reactors as solutions in n-butanol to achieve even distribution. It is expected that the n-butanol will be transformed rapidly to give products similar to natural organic materials that will not significantly affect reactor conditions over a longer time period.

3. After mixing for 48 hours to stabilize the sediment water system and before addition of reagents, three 25 gm sediment samples will be collected from each reactor and analyzed for PAHs, PCBs, total metals, organic carbon content, phosphate, sulfate, nitrate, ammonia and total sulfides; the redox potential and conductivity of the slurried mixture will also be measured. These analyses will provide a baseline of chemical concentrations and conditions for evaluating the initial system characteristics.

4. The data will be reviewed for agreement among reactors, and the variance in the concentration data calculated for the PAH and PCB components. These analyses will provide a baseline of chemical concentrations and conditions for evaluating the initial characteristics of what is expected to be an anaerobic, methanogenic condition in sediment. The data on the concentration will also be used to determine what losses of constituents may be practically measured based on the initial concentrations present and the variance in the data.

5. With continuous stirring, the following reagents will be added to each of the two reactors comprising a reactor set: oxygen via sparge tube; sodium nitrate; sodium sulfate. The remaining reactor set will have no reagents added. The reagents will be added daily until achieving a stable redox potential is achieved (+/- 30 mv for daily readings).

6. The initial reagent addition will necessarily require frequent monitoring of redox potential to achieve a stable system, which will depend on the rate of reagent consumption. The conditions of stability will be determined under the direction of the Co-Principal Investigator, and with the agreement of the Principal Investigator and the Quality Control Program Manager.

7. The continuously stirred reactors will be maintained in a 15°C temperature bath for six months.

8. The redox potential and pH of the slurried solution will be measured daily; less frequent monitoring will be conducted if the measurements indicate a stable redox and pH condition is maintained on a longer time scale. Carbon dioxide production will be measured every three days, or more frequently as required. The production of carbon dioxide, and of labeled carbon dioxide, will provide a continuing measure of oxidation of sediment organic matter and the labeled PAH over the course of the study.

9. After three months, three 25 gm samples will be collected from one reactor in each of the four reactor sets for analyses as discussed below.

10. After another 3 months (or a total of six months), the remaining four reactors will be thoroughly stirred and samples collected for analyses.

11. Stirring of the sediment mixture is conducted to provide a homogeneous media for sampling with the intent of minimizing the concentration variance due to sampling heterogeneity,

6.0 ANALYTICAL METHODS

Three samples will be collected from each reactor at the designated times for analyses. It is expected that three samples will provide a practical measure of the variance and average of PAH and PCB concentrations for assessing losses due to transformation reactions. The analytical procedures for the organic and inorganic constituents are listed in **Table SAP-3**. The reporting limits goals are also listed in the table, but may not be achievable due to expected matrix interferences.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

The variance in concentrations and evidence for loss of target chemicals as a group and as individual constituents or PCB congeners will be discussed in the report for this task. The report for the task will also address the disposition of the labeled PAH in terms of complete mineralization or incorporation into natural organic materials

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accord with the CQCPP and SQP 4.2.

TRANSFORMATION OF PCBs AND PAHs IN VADOSE ZONE SOIL PLOTS

STANDARD OPERATING PROCEDURE 30.5

1.0 PURPOSE

The following procedure is an experimental approach designed to evaluate the intrinsic remediation of PAHs and PCBs in soil plots established in the West Beach Landfill Wetlands. The data from these procedures is likely a function of soil properties, seasonal parameters, and other environmental variables that are not specifically measured, and therefore the data should not be used at other sites.

2.0 OBJECTIVE

The objectives of the procedure is to provide data to estimate the rate of transformation of PAHs and PCBs under conditions of the vadose zone soils in the West Beach Landfill Wetlands. As a specific part of this objective, the effect of vegetation in promoting these transformations will be evaluated.

3.0 REFERENCES

Hunt, J. R., P. A. Holden, and M. K. Firestone (1995). Coupling Transport and Biodegradation of VOCs in Surface and Subsurface Soils.
Holden, P. A., and M. K. Firestone. 1996. Soil Microorganisms in Soil Cleanup: How Can We Improve Our Understanding? In press, J. Environ. Qual.
Qiu, X., S. I. Shah, E. W. Kendall, D. L. Sorensen, R. C. Sims, and M. C. Engelke. 1994. Grass-enhanced Bioremediation for Clay Soils Contaminated with Polynuclear Aromatic Hydrocarbons. Bioremediation through Rhizosphere Technology. Ed. T. A. Anderson and J. R. Coats. ACS Symposium Series 563, Washington D. C.
Schwab, A. P., and M. K. Banks. 1994. Biologically Mediated Dissipation of Polyaromatic Hydrocarbons in the Root Zone. Bioremediation through Rhizosphere Technology. Ed. T. A. Anderson and J. R. Coats. ACS Symposium Series 563, Washington D. C.

4.0 SPECIALIZED EQUIPMENT

The procedure will entail establishing field plots in four in-ground containment systems, and requires a mixer of approximately one cubic meter to mix soil and reagents. The containment systems are constructed with galvanized steel sides and bottom, and lined with a polyethylene membrane.

5.0 EXPERIMENTAL PROCEDURES

5.1 A preliminary soil sampling program will be conducted in the areas of proposed study to evaluate the existing concentration distribution of PAH constituents and PCBs. This preliminary study will be used to locate areas where the highest concentrations of these chemicals are present so as to optimize the measurement of chemical loss rates.

5.2 Four soil plots, each approximately 1 m x 1 m x 1 m, will be individually excavated and placed in a mixer, and mixed until the soil is visually homogeneous. The plots will be prepared and maintained so that they will simulate the conditions of exposed soils in the wetlands area (see below). For two plots, solutions of approximately 18 gm each of selected PAHs and of Aroclor 1254 in 1 L of acetone will be added slowly to the soils during continual mixing; the

concentrations of these added chemicals will then be approximately 10 mg/kg (or 10 ppm.). The plots will be managed as follows:

<u>Plot</u>	<u>Conditions</u>
A	No chemicals added no native vegetation planted, and weeded as necessary
B	Chemicals added, native vegetation planted
C	Chemicals added, no native vegetation planted, and weeded as necessary
D	No chemicals added, native vegetation planted

5.3 Each soil plot will be placed in an in-ground containment system that 1m x 1m x 0.860 m deep. The containment system will be constructed of 16-gauge galvanized steel and double-lined with a polyethylene membrane. The bottom of the system will be sloped to one corner, with a 6-inch standpipe at this corner to allow measurement and collection of infiltrating water. The bottom of the containment system will be initially filled with 6-inches of pea gravel before the mixed soil is placed into the system. The top of the containment system will extend approximately 10-cm above ground surface so as to prevent overflow from the system, and will be covered with a wire mesh so as to prevent direct contact of fauna with soil in the plots. Additionally, a 6-inch deep drainage channel will be trenched around the plots so as to divert water from flowing or ponding into the area of the plots during storm events.

5.4. Each plot will be examined at least monthly to ensure the integrity of the plots (drainage system intact, wire mesh in place, etc.), to weed the plots, and measure water depth in the gravel layer. Water samples will be collected for analysis at least quarterly; target analytes will only be PCBs and PAHs that have been added to the plots.

5.5 For sampling of soil to monitor PAH and PCB loss, each plot will be divided into four quarters, and three 50 gm soil samples will be collected from each quarter at depth of 3 to 15 cm below the soil surface; a sample from each quarter will then be composited to give three composited samples (200 gm) and analyzed for PAHs, PCBs, total metals, organic carbon content; the redox potential and conductivity of the slurried mixture will also be measured to assess the general soil conditions that may be expected during inundation. These analyses will provide a baseline of chemical concentrations and conditions for evaluating the initial characteristics of what is expected to simulate field conditions where PAHs and PCBs are present.

5.6 The data will be reviewed for agreement among reactors, and the variance in the concentration data calculated for the PAH and PCB components; the data will also be compared to the initial data from 5.1 above to verify the expected concentration of chemicals. These analyses will provide a baseline of chemical concentrations and conditions. The data on the concentration will also be used to determine what losses of constituents may be practically measured based on the initial concentrations present and the variance in the data.

5.7 After three months, the same sampling program described in (2) will be repeated.

5.8 After another 3 months (or a total of six months), the same sampling program will be repeated.

5.9. The concentration data will be used to evaluate the loss rates of PAH constituents and PCBs in the soil plots. The data evaluation will include an assessment of the uncertainties due to analytical and spatial heterogeneity of the soil samples.

6.0 ANALYTICAL METHODS

Three samples will be collected from each reactor at the designated times for analyses. The analytical procedures for the organic and inorganic constituents are listed in Table SAP-3; PAHs will be analyzed at LBNL using EPA Method 8100. The reporting limits goals are also listed in the table, but may not be achievable due to matrix interferences.

7.0 DATA MANAGEMENT, ANALYSIS AND INTERPRETATION

It is expected that the sample collection and compositing plan will provide a practical measure of the variance and average of PAH and PCB concentrations for assessing losses in the soils plots due to transformation reactions. The statistical analyses and conclusions regarding rates of transformations and the influence of vegetation on the transformations will be discussed in the report for this task.

8.0 HEALTH AND SAFETY

The performing organization's health and safety policy and program will be complied with in all work conducted.

9.0 RESIDUALS MANAGEMENT

Under Federal Treatability Study Sample Exemption Rule, collection of hazardous wastes for purposes of conducting treatability studies are conditionally exempt from generator and transporter requirements (40 CFR parts 262 and 263).

10.0 RECORDS

Records generated as a result of performance of this SOP will be controlled and maintained in project record files in accordance with the CQCPP and SQP 4.2.

APPENDIX C
SITE HEALTH AND SAFETY PLAN

SITE HEALTH AND SAFETY PLAN

SEDIMENTS INTRINSIC REMEDIATION TREATABILITY STUDY

**SITES 2 and 17
NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA**

Contract Number: N62474-94-D-7420
Delivery Order No. 004

Submitted to:

EFA WEST (Code 0222)
Naval Facilities Engineering Command
900 Commodore Drive
San Bruno, CA 94066-5006

Submitted by:

Berkeley Environmental Restoration Center
University of California at Berkeley
461 Evans Hall, #1706
Berkeley, CA 94720-1706

Revision 1

**UNCLASSIFIED
February 1997**

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SITE HEALTH AND SAFETY PLAN
for
SEDIMENTS INTRINSIC REMEDIATION TREATABILITY
STUDY

SITES 2 AND 17

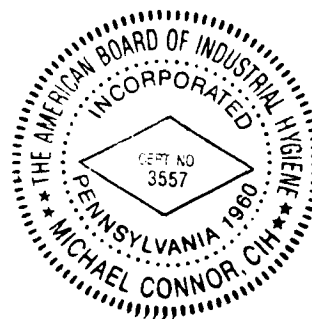
NAVAL AIR STATION ALAMEDA

CONTRACT NO. N62474-94-D-7430
Delivery Order No. 004

Revision 1

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February 1997



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ABBREVIATIONS AND ACRONYMS

(Sheet 1 of 2)

AC	-	alternating current
ACGIH	-	American Conference of Governmental Industrial Hygienists
APR	-	air-purifying respirator
ALARA	-	as low as reasonably achievable
ANSI	-	American National Standards Institute
ATG	-	Allied Technology Group, Inc.
ATSDR	-	Agency for Toxic Substance and Disease Registry
BERC	-	Berkeley Environmental Restoration Center
CAL/OSHA	-	California Occupational Safety and Health Administration
CCR	-	California Code of Regulations
CFR	-	Code of Federal Regulations
CGI	-	Combustible gas indicator
CH ₄	-	methane
CIH	-	Certified Industrial Hygienist
CPR	-	cardiopulmonary resuscitation
CPT	-	cone penetrometer testing
CRZ	-	Contamination Reduction Zone
CSE	-	Certified Safety Executive
dBA	-	decibels, measured on the A-weighted scale
DRI	-	direct-reading instrument
ECM	-	Erythema chronic migraine
EPA	-	U.S. Environmental Protection Agency
eV	-	electronvolt
EZ	-	exclusion zone
°F	-	degrees Fahrenheit
FID	-	flame ionization detector
HEPA	-	High efficiency particulate air
HSP	-	Health and safety plan (site-specific)
HP	-	Health Physics
IDLH	-	immediately dangerous to life or health
IP	-	ionization potential
LEL	-	lower explosive limit
LEPC	-	Local Emergency Planning Committee
MSDS	-	material safety data sheet
MSHA	-	United States Mine Safety and Health Administration
mg/ m ³	-	milligrams per cubic meter of air
NAS	-	Naval Air Station
NH ₃	-	ammonia
NIOSH	-	National Institute for Occupational Safety and Health
NOSC	-	Navy On-Scene Coordinator
NOSCDR	-	Navy On-Scene Commander

ABBREVIATIONS AND ACRONYMS

(Sheet 2 of 2)

O ₂	-	oxygen
OM	-	oxygen meter
OSHA	-	United States Occupational Safety and Health Administration
OVA	-	organic vapor analyzer
PCB	-	polychlorinated biphenyls
PDS	-	personnel decontamination station
PEL	-	OSHA or CAL/OSHA Permissible Exposure Limit
PI	-	Principal Investigator
PID	-	ultraviolet photoionization detector
PM	-	ATG's Project Manager
PPE	-	Personal protective equipment
ppm	-	parts per million
ROICC	-	Resident Officer in Charge of Construction
SEE	-	Steam enhanced extraction
SHSO	-	Site Health and Safety Officer
SSP	-	standard safety procedure
SS	-	Site Superintendent
SVOC	-	Semivolatile Organic Compounds
SZ	-	Support zone
TLV	-	Threshold Limit Value
TWA	-	time-weighted average
UCB	-	University of California - Berkeley
VOC	-	Volatile organic compounds

HEALTH AND SAFETY PLAN COMPLIANCE AGREEMENT FORM

All field personnel will agree in writing to comply with the provisions of this HSP, with the BERC Program Health and Safety Plan, and with ATG's Corporate Health and Safety Program, before starting field work at Sites 2 and 17. The following page contains the Health and Safety Compliance Agreement Form Attachment to be signed by all field personnel.

1. INTRODUCTION

This purpose of this site-specific Health and Safety Plan (HSP) is to describe the necessary health and safety procedures for sediments intrinsic remediation treatability study at Site 2, West Beach Landfill, and Site 17, Seaplane Lagoon, Naval Air Station, Alameda. This work, referred to as the sediments study in this HSP, has been authorized under the Partnership agreement between the U.S. Navy Engineering Field Activity West and the Berkeley Environmental Restoration Center (BERC), University of California at Berkeley (UCB). Allied Technology Group, Inc. (ATG) prepared the HSP in response to Navy Delivery Order 004) as a BERC contractor. The objectives of the sediments study are to develop and apply sediment characterization methods, to evaluate sediment toxicity indicators, to evaluate influences present on the fate and transport of metallic contaminants, and to evaluate intrinsic remediation of selected organic compounds.

Work will be conducted in accordance with the Intrinsic Sediment Processes Study, Sites 2 and 17 (Work Plan); the BERC Health and Safety Plan Program, Volumes 1 and 2, Revision 2.0, dated October 16, 1995; ATG Corporate Health and Safety Program; ATG General Management Plan; and the requirements of this HSP. The field work will be conducted by UCB personnel, ATG, and subcontractors to ATG.

This HSP is intended to protect UCB and ATG employees as well as ATG's subcontractors on site. This HSP has been prepared to assure that all Occupational Safety and Health Administration (OSHA) requirements promulgated in 29 Code of Federal Regulations (CFR) 1910.120(b)(4) Site-Specific Safety and Health Plan, and in Title 8 of the California Administrative Code, Section 5192(b)(1) are met. This document describes the health and safety procedures that will be instituted for all field activities associated with this study. This HSP references standard safety procedures described in Section 12 of the BERC Health and Safety Plan (Program) a copy of which will be available on-site. Site standard safety procedures relevant to this project are included in BERC Health and Safety Plan (Program).

This HSP will be provided to all field personnel who may be exposed to hazardous on-site conditions, including BERC, ATG, and subcontractor personnel and site visitors. Field personnel shall read this HSP and document their agreement to comply with it on the Compliance Agreement Form shown at the front of this document.

The Site Health and Safety Officer (SHSO), with the support of ATG's Project Manager (PM), will be responsible for enforcement of this HSP. Personnel who fail to follow the HSP procedures will face disciplinary action up to dismissal from the project at Sites 2 and 17. The UCB Program Certified Industrial Hygienist (CIH), in consultation with ATG's CIH, PM and SHSO, shall be responsible for resolving health and safety related questions and disputes.

2. PROJECT PERSONNEL RESPONSIBILITIES

This HSP applies to all field personnel working at Sites 2 and 17, including subcontractors and visitors. The ATG PM and the SHSO will be responsible for implementation and enforcement of the health and safety provisions of this HSP when subcontractor personnel are in the field. When only UCB personnel are in the field, Their duties are described in this section along with the duties of other project personnel.

2.1 BERC PROGRAM MANAGER

Dr. Kent Udell is the BERC Program Manager. He is responsible for reviewing and directing proposed activities and safety precautions at Sites 2 and 17.

2.2 UCB PROGRAM CERTIFIED INDUSTRIAL HYGIENIST

Mr. Mark Freiberg is the UCB Program Certified Industrial Hygienist (CIH). He has the overall responsibility for the health and safety activities at BERC project work site at Sites 2 and 17. He reviewed and approved this HSP. No changes may be made to this HSP without his written approval.

2.3 BERC PRINCIPAL INVESTIGATOR

Dr. James Hunt is the BERC Principal Investigator. As the Principal Investigator he is responsible for including safety precautions in proposed activities at Sites 2 and 17.

2.4 ATG PROJECT MANAGER

Arvind Acharya, R.G., of ATG, is the Project Manager (PM). He is responsible for the job-related health and safety of site personnel and for managing the risks associated with project equipment and facilities.

2.5 ATG CERTIFIED INDUSTRIAL HYGIENIST

Mr. Michael Connor, CIH, CSP, is ATG's CIH. Mr. Connor is responsible for developing, establishing, and coordinating the implementation of health and safety policies and procedures for ATG managed activities on BERC projects. He prepared this HSP. Mr. Connor shall also be responsible for updating this document to reflect either changes in operations or regulations. Proposed changes shall only be implemented if approved by the UCB CIH (Mr. Freiberg).

ATG's CIH will be the first point of contact on health and safety related issues for field personnel. ATG's CIH will communicate with UCB's Program CIH on all matters relating to health and safety activities at Sites 2 and 17 and on any decision made regarding health and safety activities. Accident/ Incident reports will be sent to ATG's CIH with a copy furnished to UCB's Program CIH.

2.6 SITE HEALTH AND SAFETY OFFICER

Because of the limited effort and duration of the field effort, the SHSO for this project is also Mr. Acharya. He is the primary enforcement authority for compliance with the policies and provisions of this HSP, with the BERC Health and Safety Plan (Program), and with ATG's Health and Safety Program. Mr. Acharya shall also be responsible for conducting bi-weekly site inspections to identify and to ensure that hazards previously noted have been corrected. If he cannot be on site, Mr. Acharya shall appoint an alternate SHSO who shall be approved beforehand by Dr. Hunt, the Principal Investigator.

2.7 ATG SITE SUPERINTENDENT

Mr. Acharya is the Site Superintendent (SS). He will direct all field activities including emergency response operations. Mr. Acharya will ensure necessary preparation and coordination for all site operations, including health and safety.

2.8 SUBCONTRACTOR MANAGEMENT AND PERSONNEL

Each subcontractor responsible for workers required to enter a hazardous waste site exclusion zone shall comply with the requirements of 29CFR1910.120, 8CCR5192, and with the requirements of the BERC Health and Safety Plan (Program) and of this HSP. Compliance with these requirements is not intended to either supersede or replace the contractor's own illness and injury prevention plans required by 8CCR3203. Responsibilities of subcontractor management and personnel are described further in Section 2.5 of the BERC Health and Safety Plan (Program).

2.9 VISITORS

Site visitors are also required to adhere to this HSP. Either the ATG Project Manager or the SHSO shall brief site visitors on site health and safety hazards when they first arrive on site. In general, site visitors will not be allowed access to contaminated areas (exclusion zones) unless they have demonstrated compliance with the medical surveillance and training requirements of this HSP. The responsibilities of visitors to Sites 2 and 17 are further described in Section 2.7 of the BERC Health and Safety Plan (Program).

3. HAZARD ANALYSIS AND CONTROL PROGRAM

3.1 PROGRAM OVERVIEW

This section describes the site, summarizes the tasks to be conducted as part of the Intrinsic Sediments Processes Study, and discusses the hazards associated with the field work.

3.1.1 Site Location

Sites 2 and 17 are located at NAS Alameda. A "Site Location Map" is shown as Figure 3-1. NAS Alameda is located on the western end of Alameda Island.

The West Beach Landfill (Site 2) occupies approximately 110 acres in the southwestern corner of NAS Alameda. It is bound on the west and south by San Francisco Bay; and by a fence on the north and east sides. The former landfill is surrounded by an earthen berm approximately 55 feet wide and about 7 feet above the landfill surface. It is moderately to well vegetated and contains wetlands (i.e. marshy terrain) in some areas.

Site 2 was used as waste disposal landfill from 1952 to 1978. Approximately 1.6 million tons of waste, 30,000 to 500,000 tons of which were considered hazardous, were placed at this facility. Known wastes at Site 2 include drums; solvents; oils and sludges; paints, strippers, thinners, and plating wastes; industrial strippers and cleaners; acids; mercury; PCB-contaminated fluids; batteries; low-level radioactive materials; scrap metals; inert ordnance; creosote; dredge spoils; and waste medicines and reagents; spoiled food; asbestos; pesticides (solid and liquid); tear gas agent ortho-chlorobenzylidene malononitrile (CS); infectious wastes, and municipal wastes.

The Seaplane Lagoon (Site 17) is located at the southeastern corner of NAS Alameda (Figure 3-2). This lagoon has a surface area of 110 acres; is 12 to 17 feet deep and is almost entirely surrounded by seawalls. Entrance to it is through an opening in the breakwater which extends from Pier 1. The lagoon is approximately 800 feet long and is subject to tidal circulation. Nearby are berths for deep draft ships.

From 1943 to 1975, the lagoon was used as a receiving basin for an estimated 300 million gallons of wastewater from the combined storm and sanitary sewer system which received wastewater from many industrial operations throughout NAS. In 1975 industrial wastewater was segregated from the system so that discharges into the lagoon consisted only of storm sewer discharges and surface runoff (PRC, 1994a).

Wastewater discharged to the Seaplane Lagoon before 1975 was reported to contain metals, solvents, paints, detergents, acids, caustics, mercury, oil and grease, and PCBs. Ships docked at the piers south of the entrance discharged wastewater containing solvents, chromium, waste oil, and fuel which could have been swept into the lagoon by tidal action.

3.1.2 Project Summary

This section provides a summary of the work needed to complete the sediment study at Sites 2 and 17. The work essentially consists of two types of activities: sample collection at both sites and acoustic imaging the bottom of the lagoon (Site 17). Site 2 sample collection shall consist of hand augering to collect core samples, groundwater sampling, and soil gas sampling. The latter shall consist of the installation of equipment to sample soil off-gassing. Trained field workers will collect lagoon sediment samples from Site 17 either from a Boston Whaler or other suitable vessel. Acoustic imaging will be from a small barge towed by a shallow draft vessel in specified patterns. This vessel shall be contracted with crew from a commercial vessel operator.

3.2 HAZARD ANALYSIS

Sample collection at Site 2 will be associated with chemical and physical hazards. Chemical hazards could arise from direct contact with contaminated materials during soil sample collection. Inhalation exposure is expected to be very low since known contaminants are below ground and are present at low concentrations and since borings will represent short term point sources. The low dermal hazard will be mitigated through the use of personal protective clothing as described in Section 7.1 of this HSP. The chemical hazards associated with groundwater sampling would be similar and lower for soil gas sampling since equipment installation does not require intrusive procedures. The primary physical hazard associated with work at Site 2 is slip trip and fall from work on wetlands or marshy grounds. This will be primarily mitigated through the use of buddy teams and careful work practices.

Sediment sample collection at Site 17 will also be associated with chemical and physical hazards. Chemical hazards may arise from incidental contact with contaminated materials during sample collection. This hazard is expected to be lower than sample collection at Site 2 since the work will involve sampling essentially Bay muds. The primary physical hazards associated with sample collection are either drowning or hypothermia. The hazards associated with acoustic imaging are primarily water related since the work will occur on a towed barge. Section 11.3 details water safety procedures.

Attachment 3-2 is the Job Hazard Analysis form for planned site activities as described in Section 3.2 of the BERCC Program Health and Safety Plan.

3.2.1 Chemical Hazards

Table 3-1 lists the contaminants known to be on Site 2. These contaminants can be classified into volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, and pesticides. Exposure to these substances could arise through inhalation, skin contact and ingestion. Each of these routes of exposures is discussed below. Figure 3-3 contains a summary of the adverse effects of known site contaminants.

Overall, inhalation exposure to contaminants at Site 2 is expected to be below applicable federal and California PELs because known contaminant content is comparatively low and because recent sediment sample collection work in the lagoon showed no detectable VOCs. The same would apply to Site 17 because it is expected that VOC content in sediments would be low since these substances tend to float.

Although some VOCs known to be present on site are flammable, the fire and explosion hazard is not anticipated to be significant because of the aqueous nature of the samples. Furthermore as most flammable and combustible liquids have a higher specific gravity than water, they are very unlikely to be present in sufficiently high concentrations to present either a flammable or a toxic hazard.

It is possible there could be hydrogen sulfide (H₂S) exposure from residual subsurface petroleum products. Although this hazard is unlikely during sediment sampling, this potential hazard will be evaluated through periodic monitoring with a direct H₂S reading monitor.

H₂S is an acutely toxic gas which can be fatal at relatively low concentrations (500 ppm). Exposure to lower concentrations may cause eye and respiratory irritation. The current CAL/OSHA PEL for this substance is 10 ppm on an 8 hour time weighted average. Although the rotten egg-like odor of H₂S is easily detectable at low concentrations, its odor is not a reliable warning because the olfactory system becomes desensitized during prolonged exposure. High concentrations, may cause loss of consciousness, dizziness and upset stomach. The chronic effects of exposure to H₂S are negligible.

Dermal exposure to site contaminants is more likely than inhalation, particularly during direct contact with contaminated materials. This could occur when collecting either soil, groundwater or sediment samples, when cleaning sampling equipment or other related equipment. However, the use of personal protective equipment as described in Section 8 of this HSP will minimize this occasional hazard. Ocular exposure shall be minimized through the use of appropriate eye protection.

Ingestion exposure to site contaminants is also expected to be low because eating, drinking and smoking shall be forbidden during sampling activities, and because personal decontamination is required when concluding sample handling and equipment cleanup.

3.2.2 Physical Hazards

There are a number of physical hazards associated with the pilot study, the most significant of which is working on or near water. San Francisco Bay water temperatures average 58°F which exacerbates drowning hazards because of rapid hypothermia. Section 11.4 contains standard safety procedures for working on or around a body of water. Section 3-1 references the corresponding standard safety procedures from Section 12 of the BERC Program Health and Safety Plan (Program) for these hazards.

3.2.2.1 *Slip, Trip, and Fall Hazards*

Slip, trip, and fall hazards may be present at Sites 2 and 17. Such hazards will be identified and reviewed by the SHSO at the daily health and safety meeting before field work begins. Slip, trip, and fall hazards are discussed in Section 12.17 of the BERC Health and Safety Plan (Program). Work on Site 2 shall be in pairs (buddy system) who shall remain in sight of each other.

3.2.2.2 *Electrical Hazards*

Sample collection at both sites is not expected to be associated with electrical hazards. However, the acoustic imaging system, (a commercially available unit IKB-Seistec Model B3, IKB Technologies Ltd., Dartmouth, Nova Scotia, Canada) requires operating voltages of up to 3,000 Volts provided by a Seismic Energy Source Model 234 (EG&G Environmental Equipment, Burlington, MA). This hazard, while potentially serious, is not expected to be significant because both units are designed for outdoor use over bodies of water. Furthermore, the equipment will undergo a thorough operational review by Mr. Keith Gershon, a Lawrence Berkeley National Laboratory Environmental Health and Safety electrical safety officer with an electrical engineering degree. Furthermore, Mr. Pat Williams, the field operator of this equipment, who has received manufacturer training on the safe operation of this equipment, is an experienced operator. Section 11.4 describes the standard safety procedures for acoustic imaging work.

3.2.2.3 Heat and Cold Stress

Heat stress is a potential hazard during warm months due to physical exertion associated with construction activities while wearing personal protective clothing. When ambient temperatures reach 70 degrees Fahrenheit (° F) and workers are wearing personal protective clothing, work-rest cycles will be scheduled on a regular basis and liquids with electrolytes will be available to replenish body fluids. The PM and SHSO shall establish the work rest cycles as necessary. This shall be discussed during tailgate safety meetings.

Because the incidence of heat stress depends upon a variety of factors, all workers, even those not wearing personal protective equipment (PPE), will be observed and instructed to report any symptoms of heat stress.

Section 12.15 of the BERC Health and Safety Plan (Program) contains the standard safety procedures for handling heat stress-related hazards. It shall be discussed during the site specific training and reviewed as necessary during tailgate safety meetings.

Cold stress is a potential hazard for this project particularly during work on Site 17 should clothing become wet. This shall be avoided through the use of PVC raingear or other waterproof clothing which shall be required when working on water and during wet weather. Site workers shall be encouraged to dress in layered clothing to stay warm and to bring a change of warm dry clothing. The signs and symptoms of hypothermia shall be reviewed at a tailgate safety meeting. Site workers shall work under the buddy system when either conditions or activities predispose the potential for cold stress. Employees shall be reminded of the importance to stay warm and to observe each other for shivering. If shivering occurs, activities shall be suspended and the affected employee(s) shall be taken to a warm and dry location to allow rewarming, and change of clothing as necessary.

3.3.3 Biological Hazards

Sites 2 and 17 do not currently have flora and fauna that would present a biological hazard. However, the ATG Project Manager or the SHSO shall inspect the site before field work begins to ensure the absence of such hazards. This shall be discussed during the site specific training as needed. Additionally, the SHSO shall conduct routine inspections to ensure there are no new biological hazards present. Section 12.24 of the BERC Health and Safety Plan (Program) contains the standard safety procedures for biological hazards.

4. TRAINING REQUIREMENTS

Work in the exclusion zones of the project will require completion of a 40 hour hazardous waste class. Site supervisors shall also have completed an appropriate 8 hour supervisor course. Persons visiting the sites infrequently or for short durations (such as transporting equipment or samples to laboratories) shall have a minimum of 24 hour training. This general training shall be updated annually. These training requirements are described in detail in Section 4 of the BERC Health and Safety Plan (Program).

Site specific training is also required for all site personnel. The content of this training will depend on the activities to be conducted. Attachment 4-3 contains an example of a tailgate health and safety form to record topics covered. The following is an outline of the site specific training:

- Site roles and responsibilities:
- Site hazards
- Water safety (Site 17)
- Site controls

- Site personal protective equipment
- Site decontamination procedures
- Applicable standard safety procedures (See Table 3-1)
- Emergency preparedness:
 - Communications
 - Location of emergency facility
 - Evacuation/muster points
 - Man overboard (Site 17)

Additionally, vessel operators shall be trained on the safe operation of vessels used during this project. The minimum acceptable training shall be completion of the U.S. Coast Guard Auxiliary Boating and Seamanship course (or equivalent).

Personnel without site specific training shall not be permitted into exclusion zones. Visitors are required to adhere to this training requirement.

There will be one individual current in first aid and CPR training on site during all field work.

5. MEDICAL SURVEILLANCE

All BERC, ATG, and sub-contractor personnel that will be working either with contaminated materials or in an exclusion zone shall participate in an annual medical surveillance program in accordance with federal and state requirements. A California licensed and certified physician shall clear workers to wear respiratory devices and protective clothing as required.

Field personnel shall receive pre-placement examinations and annual re-evaluations to update clearances. Documentation of examinations shall be provided to the Navy five working days prior to the Preconstruction Meeting. The SHSO shall communicate medical restrictions to the affected employee whose work tasks shall be revised to be consistent with terms of the restrictions. Employees leaving their positions shall also be provided with an exit physical, if they have not had an annual re-examination in the preceding six months. Medical surveillance requirements for field personnel are further described in Section 5 of the BERC Health and Safety Plan (Program).

6. SITE CONTROL

Site control procedures specified in Section 6 of the BERC Health and Safety Plan (Program), and include exclusion zone (EZ), contamination reduction zone, support zone and site security. The EZ is the project area where there is actual or potential contamination of equipment and personnel. Personal protective equipment as described in Section 8 of this HSP shall be worn in the EZ. Visitors will not be permitted to enter the EZ without the authorization of the SHSO. Authorization shall be granted only if visitors meet the same medical and training requirements as project field personnel. Entry to the EZ shall be restricted to the minimum number of personnel, and only under the buddy system. Either the ATG PM or SHSO will also log all employees and visitors who enter the EZ.

The specific location of the EZ will vary according to task. For example, the exclusion zone (EZ) will extend at least 10 feet from all drilling and sampling activities at Site 2 and will be marked by cones, barricade tapes or other equivalent methods. These EZs shall be terminated when boreholes have been either covered or backfilled. An EZ is not necessary for activities which do not disturb subsurface contaminants. On the other hand, the exclusion zone for the sediment sample collection at Site 17 shall be the area behind the boat operator's station on the Boston Whaler. A CRZ is not required for acoustic imaging work since it does not require direct contact with contaminated materials or samples.

The contamination reduction zone (CRZ) will be immediately adjacent to and upwind from the EZ, except on the Boston Whaler used for sediment sample collection. In this case, the EZ shall be used as the CRZ when sample collection is completed. The CRZ shall be used to clean contaminated tools and equipment and to doff personal protective equipment.

The support zone (SZ) will be situated in a clean, uncontaminated area outside the CRZ, where exposure to either hazardous materials or conditions is minimal. Contaminated equipment, samples, or personnel are not permitted in the SZ. The office trailer shall be installed in the SZ.

7. PERSONAL PROTECTIVE EQUIPMENT

The variety of tasks associated with the sediments study will require different levels of personal protective equipment (PPE) as described below and listed in Attachment 7-4. PPE requirements for activities which do not require contact with site contaminants shall consist of the following:

- Hard hat
- Safety glasses with side shields
- Long-sleeved shirts
- Cotton or leather gloves
- Foot wear with steel toe and shank

The SHSO shall review field PPE needs on a periodic basis in accordance with the guidelines shown in Section 7 of the BERC Health and Safety Plan (Program). PPE requirements shall be reviewed during tailgate safety meetings as necessary.

As described in Section 3.2, site work is not anticipated to require more than EPA level D PPE. However, as discussed in Section 9, air monitoring will be used to confirm that respiratory protection is not necessary. Respiratory protection shall be selected based on air monitoring results and shall be reviewed and approved by Mr. Michael Connor, CIH.

7.1 SITE 2

The PPE required in exclusion zones associated with either soil boring work or other activities with actual or potential exposure to site contaminants will consist of the following modified level D ensemble:

- Hard hat
- Safety glasses with side shields
- Polyethylene coated Tyvek suits
- Nitrile gloves with surgical inner gloves
- PVC or neoprene boots with steel toe and shank

Site visitors not required to work in the exclusion zone shall wear PVC or neoprene boots with steel toe and shank and Polyethylene coated Tyvek suits to minimize incidental contamination. Footwear shall be cleaned before exiting the site.

7.2 SITE 17

PPE requirements for sediment sample collection shall consist of the following:

- Coast Guard approved personal flotation device
- Safety glasses with side shields
- PVC or other waterproof raingear
- Nitrile gloves
- PVC or neoprene boots with steel toe and shank

Nitrile gloves may be substituted for cotton work gloves for acoustic imaging work as this will not involve direct contact with contaminated materials.

8. DECONTAMINATION

The sediments study field work shall require basic decontamination procedures mostly during sample collection at Sites 2 and 17. The installation of soil gas sampling equipment at Site 2 and acoustic imaging at Site 17 will not require any specific decontamination procedures other than good personal hygiene because this work will not involve direct contact with contaminated materials. Decontamination procedures shall be discussed during site specific training and reviewed during tailgate safety meetings.

8.1 DECONTAMINATION PROCEDURES

The following decontamination stations shall be used in the designated CRZ for decontamination during soil and groundwater sampling activities at Site 2:

- 1) Segregated equipment drop. Drop equipment used on site (hand tools, monitoring equipment and sampling containers, radios, clipboards, etc.) on plastic drop cloths or in containers with plastic liners.
- 2) Boot cover, outer glove, and outer garment wash and rinse. Scrub boots, outer gloves, and outer garment with decontamination solution or detergent water. Rinse off decontamination solution or detergent water using copious amounts of water. Repeat as necessary.
- 3) Removal station for boot covers and outer gloves. Remove duct tape around boots and gloves and deposit in container with plastic liner.
- 4) Removal station for outer garment. With assistance of a helper, remove protective garment and deposit it in container with plastic liner.
- 5) Hand and face wash and rinse. Wash hands and face.

These procedures may be modified during sediment sample collection at Site 17 where the EZ shall become the CRZ at the completion of sample collection each day. In this case, the decontamination procedures shall consist of sealing all sample containers and cleaning them of external residues. Only clean sample containers shall be transported offsite or handled by other personnel. Protective clothing shall be washed off as shall the Boston Whaler before the boat leaves the site.

Decontamination, other than cleaning off footwear before leaving work areas and good personal hygiene practices, is not required for site visitors or other personnel whose work has not required them to handle contaminated materials directly (e.g. acoustic imaging work).

8.2 DISPOSAL PROCEDURES

Used but clean disposable protective clothing will be double-bagged and placed in drums for disposal as ordinary waste. Disposable sampling tools and visibly contaminated protective equipment shall be double bagged and disposed of appropriately based on analytical results from soil or groundwater samples. Wash and rinse waters will be collected in drums and disposed of based on analytical results.

8.3 DECONTAMINATION DURING MEDICAL EMERGENCIES

If prompt life-saving first aid or medical treatment is required, decontamination procedures will be omitted as needed. Since site work will not result in significant contamination of protective clothing, it

shall be cut away or removed before transportation to the emergency facility. On-site personnel will accompany contaminated victims to the medical facility to advise on matters involving decontamination. This is not anticipated to be a significant issue since the field work is not expected to be associated with significant exposure to contaminants. Section 8.4 of the Health and Safety Plan (Program) provides additional details on emergency decontamination procedures.

9. EXPOSURE MONITORING

The purpose of exposure monitoring is to ensure that personnel are adequately protected and to verify that site chemical hazards have been properly evaluated. Figure 9-5 list exposure guidelines for chemical hazards known to occur in the project areas. As stated in Section 3.2, significant exposures are not expected. The exposure monitoring necessary during the sediments study shall consist of use of a direct reading H₂S monitor, and a combustible gas indicator (CGI) whenever there is subsurface soil disturbance. This equipment shall be used by individuals trained on the equipment's use and limitations. The equipment shall be calibrated and used in accordance with the manufacturer's instructions before and after use. These instructions shall be included in the SHSP when the equipment is procured and before field work begins. Results shall be recorded as shall be recorded as shall the date, time, weather conditions, work activity, and name of person conducting the monitoring. These records shall be available on site. The ATG Project Manager or the SHSO are responsible for ensuring the necessary monitoring is conducted by trained personnel.

The direct-reading H₂S monitor shall be used to monitor potential exposures to this gas in accordance with the guidelines shown in Section 9.1 of this HSP. This instrument shall be used primarily during soil boring operations.

The CGI shall be used to verify that there are no flammable gases present at ignitable concentrations during soil boring work. As discussed in Section 4 of this HSP, such concentrations are not anticipated. Nonetheless, the work areas shall be monitored periodically to ensure there is no fire or explosion hazard associated with the site contaminants.

Exposure monitoring results shall be discussed with affected employees during each day of air monitoring. The results shall be recorded and shall be available on site.

9.1 ACTION LEVELS

This section describes the criteria against which air monitoring results shall be evaluated. These levels are as measured in worker breathing zones and as sustained for a period of five consecutive minutes. Respiratory protection may be downgraded when results fall below the specified criteria for five consecutive minutes.

9.1.1 Hydrogen Sulfide

Normal Background Levels	=	Level D protection
Above Background Levels		
>0 to 5 ppm	=	Increase monitoring frequency (every 15 minutes)
>10 ppm	=	Stop work; evacuate site; call ATG CIH

9.1.2 Explosive Atmospheres

0 to 10% LEL	=	Normal background levels
> 10% LEL	=	Stop work; evacuate site; call ATG CIH

During operations with live steam, the CGI and PID will be used to check all work areas within the exclusion zone before initiating work activities. When activities within the work zone involve only monitoring, CGI and PID readings will be taken near each monitoring point once each day or when emissions are observed.

If H₂S was observed during the drilling operation at concentrations greater than 50 ppm, then H₂S will be monitored during the steaming operation at the same frequency as CGI and PID measurements. Otherwise, H₂S will be monitored only if observed in the extracted vapors at concentrations greater than 50 ppm.

10. EMERGENCY RESPONSE

The following sections discuss general first aid procedures, hospital and evacuation route, emergency resources, emergency response telephone numbers, and accident/incident reporting. The site superintendent directs emergency response operations.

The ATG SS or the SHSO shall be notified of fires spills or leaks to assess the situation and determine the response. All personnel not trained in spill control shall evacuate the area. Only 40 hour Hazwoper trained personnel may be used to respond to emergencies. The Base Fire Department shall be called for large fires or for responses to spills or releases in excess of 50 pounds or 50 gallons. The location and type of fire suppression equipment at the project site will be determined during site construction.

10.1 SITE EMERGENCIES

Major site emergencies such as chemically related injury or fatality, fires and explosions shall require the site to be evacuated. This shall be announced by five long blasts of the alarm. Employees shall muster at the entrance to Sites 2 and 17 unless otherwise directed. A map of the muster point shall be available on site. Drains or other offsite pathways shall be diked off with either soil or sorbent materials. The Base Fire Department shall be contacted to extinguish major site fires.

The most significant emergency that could occur during the sediments study is falling overboard during work on the Seaplane Lagoon. For this reason, man overboard procedures shall be reviewed with all applicable personnel before work on the Boston Whaler begins.

Minor site emergencies include small spills (less than 50 gallons or 50 pounds) of contaminated materials, or small fires. Personnel shall report these emergencies without delay. Either the SS or the SHSO shall direct response actions, the first being to isolate the affected work area. Small spills shall be contained with sorbent materials. Small fires shall be put out with fire extinguishers. First aid incidents shall be handled as described in Section 10.2. As stated in Section 8.3, emergency decontamination procedures shall consist of the removal of contaminated clothing before either treatment or transportation of the victim(s).

The SHSO shall investigate all site emergencies after they have been mitigated to determine whether responses were satisfactory and to determine appropriate corrective actions. This may result in modifications to this HSP. These modifications shall be submitted for approval by the UCB Program CIH before they are implemented.

10.2 GENERAL FIRST AID PROCEDURES

There will be two first aid/CPR trained person on site during field activities. These persons shall also be trained on bloodborne pathogens as required by Section of the BERC Health and Safety Plan (Program). These individuals shall be identified during routine tailgate safety meetings. A first aid kit shall be kept available on site.

Dermal Exposure: Wash with soap immediately and rinse with copious amounts of clean water. Watch for signs of skin irritation. Seek medical attention at first signs of irritation.

Inhalation: Move victim to fresh air. Give artificial respiration if necessary. Observe victim for signs of shock. Seek medical attention immediately.

Ingestion: CALL POISON CONTROL CENTER. Seek immediate medical attention. If possible, a sample of ingested material will be collected and transported to hospital with the victim.

10.3 HOSPITAL AND EVACUATION ROUTE

During site mobilization, ATG personnel will conduct a pre-emergency run to Alameda Hospital - 2070 Clinton Avenue - (510) 523-4357 emergency room, and (510) 522-3700 hospital. The purpose of this is to (1) familiarize personnel with the route to the hospital; and (2) notify the hospital of the planned site activities and potential medical needs. An emergency route to the East Gate is shown in Figures 10-1 and 10-2. A "Hospital Route Map" is shown in Figure 10-3.

To reach the Alameda Hospital, exit the NAS site through the East Gate. Cross Main Street, continuing East on Atlantic Avenue. Turn right onto Webster Street, then left on to Central Avenue. Take Central and then a 90 degree right turn onto Sherman Street. Turn left onto Clinton Avenue Emergency room entrance in on the right hand side of Clinton Avenue, between Chestnut Street and Willow Street.

10.4 EMERGENCY RESOURCES

Before work begins at each site, contact will be made with local authorities and emergency services to establish communication channels during an event of emergency and to familiarize the project personnel with the communication procedure and services. Pertinent emergency information will be included at the daily tailgate safety meetings.

From a base telephone (found in all government offices)

On base calls: Dial "3" plus the last 4 digits of an on-base number

Off base calls (local): Dial "9" plus the 7 digit number

Off base calls (long distance): Dial "91" plus the area code and 7 digit number,

Public Agencies

Fire	(Base)		(510) 263-4300
	(Alameda City)	911 or	(510) 522-2423
Ambulance			(510) 263-4444
Police	(Alameda City)	911 or	(510) 522-2423
OSHA			(415) 744-6670
Cal/OSHA	(Oakland)		(510) 568-8602

Key Project and BERC Personnel

Program Manager (Kent S. Udell)	(510) 642-0922 (510) 643-1300
Principal Investigator (James R. Hunt)	(510) 642-0948 (510) 643-1300
Program CIH (Mark Freiberg)	(510) 643-8676 pager (510) 430-5038

Allied Technology Group (ATG) CIH (Michael Conner)	(415) 252-0778 pager (415) 245-4501
Project Manager (Arvind Acharya)	(510) 490-3008 home (510) 522-0390
Project Superintendent (Arvind Acharya)	(510) 490-3008 pager (800) 690-3573
Site Health and Safety Officer (Arvind Acharya)	(510) 490-3008 pager (800) 690-3573
Occupational Health Physician (Thomas Gamsky, M.D.)	(510) 643-7116
Navy Remedial Project Manager (Ken Spielman)	(415) 244-2539
Navy Contact [Resident Officer in Charge of Construction (ROICC)] (Wayne Coffey)	(510) 302-3354
Base Health and Safety Office	(510) 263-3395
Agency for Toxic Substance and Disease Registry (ATSDR)	(404) 639-0615
Navy On-Scene Coordinator (NOSC)	(510) 263-3276
Navy On-Scene Commander (NOSCDR)	(510) 263-3003
Local Emergency Planning Committee (LEPC)	(510) 263-3050
Regional Poison Control Center	(510) 476-6600

Medical Care Facilities

Hospital Name:	Alameda Hospital
Hospital Address:	2070 Clinton Avenue Alameda, CA
Alameda Hospital Telephone:	(510) 522-3700
Alameda Emergency Room	(510) 523-4357
Base Medical:	(510) 263-4444

Regulatory Agencies:

California State Office of Emergency Services	(510) 646-5908
Fish and Game	(800) 952-5400
Regional Water Board	(510) 464-1255
CHEMTREC	(800) 424-9300
Poison Control Center	(800) 356-3129
Underground Services Alert	(800) 642-2444
Base Hot Work Permits	(510) 263-3279

10.5 ACCIDENT/INCIDENT REPORTING

Accidents and incidents shall be reported on the form contained in Attachment 10-5, "Accident/Incident Report Form," in accordance with BERC's Health and Safety Plan and ATG's Corporate Health and Safety Program. The accident/incident form will be forwarded to ATG's CIH. Reportable events that may occur on a BERC project work site include:

- Injuries - injuries to personnel of any magnitude
- Toxic agent exposure - any exposure of inadequately protected personnel to toxic agents

- Personnel radiation contamination - personnel exposures to radiation contamination
- Back injuries - back injuries that require treatment by a clinic or chiropractor
- Near miss - incident in which an injury could have occurred and which requires either preventive or corrective action to prevent re-occurrence
- Tool or equipment failure - failure that results or could result in serious injury
- Vehicle accidents - any magnitude collision or malfunction
- Property damage - ATG, client or private property
- Fire or explosion - any magnitude
- Fatality - any accident that results in the death of an employee, client, or visitor at the BERC project work site.

A copy of the completed Accident/Injury form shall be submitted to the Resident Officer in Charge of Construction within the prescribed timetable.

11. STANDARD SAFETY PROCEDURES

This section describes certain standard safety procedures relevant to the sediments study. This section is not intended to either supersede or replace safety procedures described in the BERC Health and Safety Plan (Program).

11.1 SITE ENTRY PROCEDURES

All field personnel shall attend a site orientation meeting before work starts at the site. Thereafter, an on-site health and safety meeting will be held at the beginning of each work day to discuss pertinent health and safety issues. Attachment 3 contains a Safety Meeting Sign-Off Sheet for persons who attended the meeting.

11.2 STANDARD WORK PRACTICES

Standard health and safety work practices in exclusion zones at Sites 2 and 17 NAS Alameda include the following:

- Contact with potentially contaminated substances should be avoided. Field personnel shall not walk through puddles, pools, mud, etc., and shall avoid, whenever possible, kneeling on the ground, leaning, or sitting on equipment on the ground.
- All field work shall be with the buddy system.
- Containers (such as drums) will be moved only with the proper equipment and will be secured to prevent dropping or loss of control during transport.
- Equipment will not be placed on potentially contaminated surfaces, including but not limited to the ground.
- Portable eyewash stations will be located near individual work sites.
- Eating, drinking, chewing tobacco, smoking, and carrying matches or lighters, and using cosmetics are prohibited in EZ and CRZ, or where the possibility for the transfer of contamination exists.
- During rest periods, all personnel will be required to wash their hands and faces before eating, drinking, smoking, or applying cosmetics.
- All field team members should make use of all their senses to alert them to potentially dangerous situations in which they should not become involved, i.e., presence of strong and

irritating or nauseating odors.

- Site personnel will observe each other for signs of toxic exposure and heat or cold stress. Indications of adverse health effects include but are not limited to the following:
 - Changes in complexion and skin discoloration
 - Changes in coordination
 - Changes in demeanor
 - Excessive salivation and papillary response
 - Changes in speech patterns
- Site personnel will inform each other of non-visual effects of illness, such as the following:
 - Headache
 - Dizziness
 - Nausea
 - Blurred vision
 - Cramps
 - Irritation of eyes, skin, or the respiratory tract
- Spills should be prevented to the greatest extent possible. In the event that a spillage occurs, contain liquid if possible.
- Splashing of the contaminated materials shall be avoided.

All hazardous wastes generated during ATG's and/or subcontractor activities should be disposed of as directed by the SHSO.

11.3 WATER SAFETY

The following procedures shall be followed whenever working on a vessel or other floating equipment:

- The vessel shall be operated by a qualified operator.
- The vessel shall be maintained in safe working order and shall be currently licensed in California.
- Safe means of access and egress to the vessel shall be provided.
- The vessel shall conform to U.S. Coast Guard requirements for its use.
- The vessel shall be fitted with a U.S. Coast Guard approved 30 inch life ring with at least 90 feet of 600 pound capacity line.
- All individuals aboard the vessel must wear U.S. Coast Guard approved personal flotation devices. These shall be inspected every week. Damaged PFDs shall not be used.
- The vessel operator shall review the man overboard procedure with all individuals aboard before work begins.
- The vessel shall be fitted with a marine band VHF radio.
- Individuals shall stay clear of towing bridles or other lines under stress.
- Towing bridles shall be inspected weekly. Damaged equipment shall be taken out of service.

11.4 ACOUSTIC IMAGING SAFETY

The following procedures shall be followed when using the IKB Seistec Model B3 acoustic imaging equipment:

- Only individuals trained on this equipment shall operate it.
- The equipment shall be inspected by an LBNL Environmental Health and Safety electrical engineer before use. A record of this inspection shall be kept on site.
- The equipment shall not be used until the appropriate grounding provisions have been made.
- The high voltage cable shall be marked with orange tape or equivalent.
- The location of the power cut off shall be reviewed with all applicable personnel before acoustic imaging begins.
- Equipment power cables shall be routed to avoid any pinching or chafing. This shall be inspected periodically during equipment use.
- Stress on the power cable shall be relieved through the use of suitable towing bridles or ropes. Towing bridles and ropes shall be suitable for the load and shall be inspected weekly. Damaged equipment will be tagged out of service.
- Only manufacturer trained personnel shall service this equipment or its power source. Neither shall be repaired or serviced without the appropriate lock out and tag out procedures as detailed in Section 12.6 of the BERC Health and Safety Plan (Program).
- The on board AC generator shall be fitted with ground fault interrupters and shall be approved for use in wet locations.
- There will be no work on the Lagoon when waves are larger than 1.5 feet or when weather conditions do not permit safe operation of the vessel.

11.5 RECORD KEEPING

The health and safety record keeping requirements are an important component of UCB Health and Safety Program and ATG's Health and Safety Program. The following list highlights the record keeping requirements for BERC field staff and ATG's employees and site-specific activities. The items will be retained by ATG for 30 years after each covered employee has ended employment with BERC or ATG, respectively.

- Medical surveillance results for each of BERC's or ATG's employees
- Names, addresses, and phone numbers of examining and consulting physicians and clinics
- A copy of respirator fit test results
- A copy of training certificates for initial 40 hours of project work site training, SHSO training, 8 hours of supervisor's health and safety training, 8 hours of annual refresher training, CPR and first aid training, and any other training received
- A copy of employee CPR and Red Cross certificates

The following records will be retained by ATG for 30 years after close-out of delivery order 3 at a BERC project work site managed by ATG:

- Copies of UCB's and ATG's Health and Safety Programs
- Records of site visits by ATG's employees and subcontractors
- A copy of pages from logbooks on field calibration of health and safety monitoring equipment for air sampling and other field issues related to health and safety
- All health and safety survey reports
- Accident/incident reports

12. SANITATION

An adequate supply of potable drinking water shall be available at work sites outside designated exclusion zones. Disposable drinking vessels shall be provided. These shall be neither shared nor re-used.

The location of the nearest toilets shall be identified at the beginning of each days field activities. Ample time shall be allowed to access these facilities as needed.

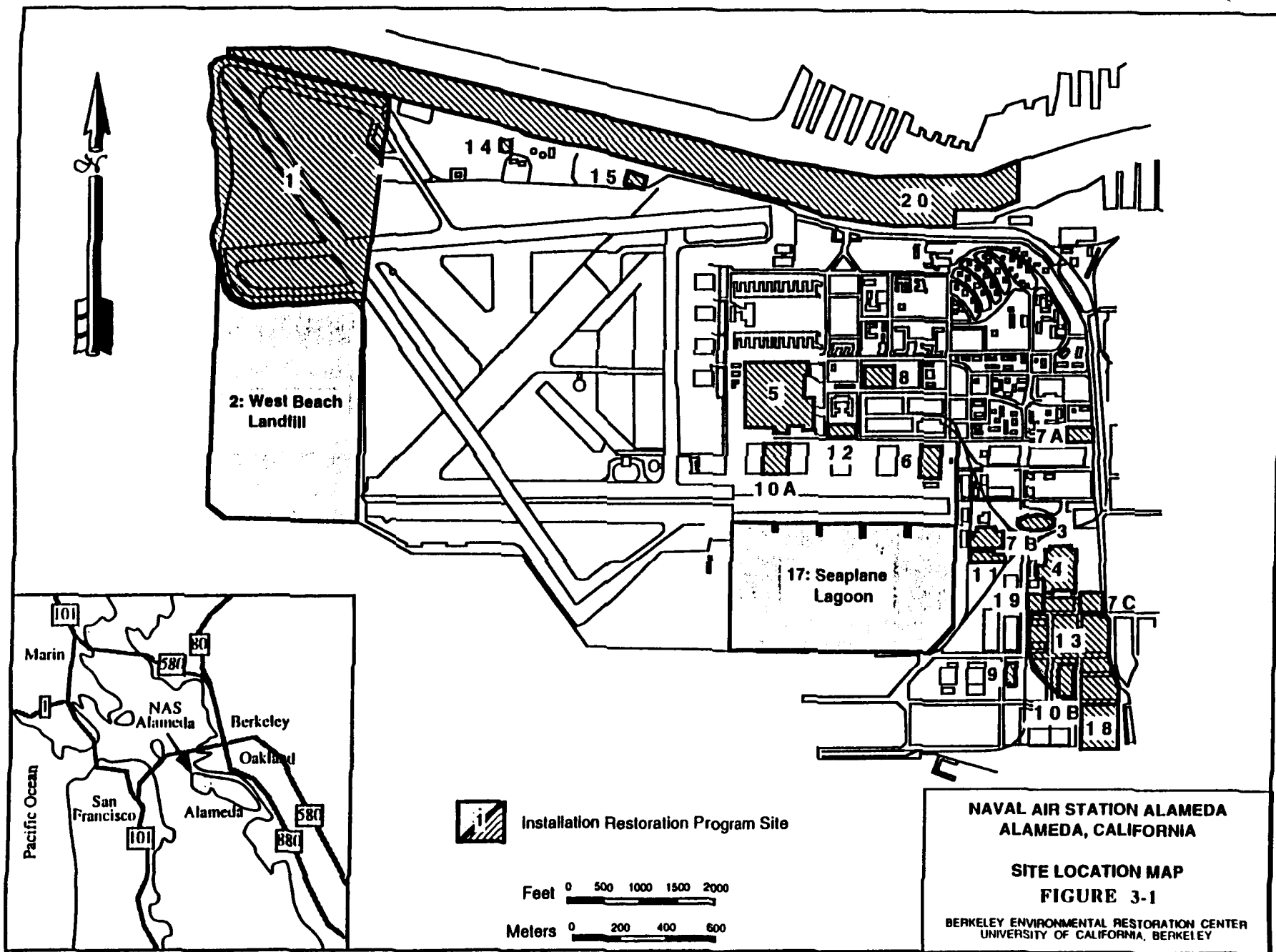
**TABLES
&
FIGURES**

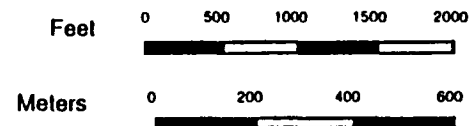
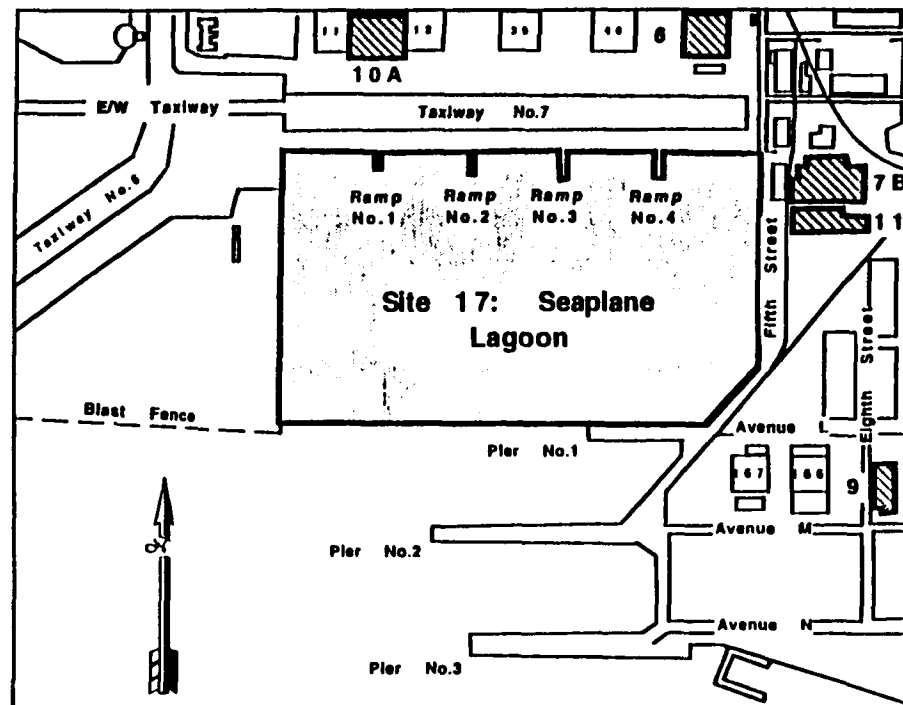
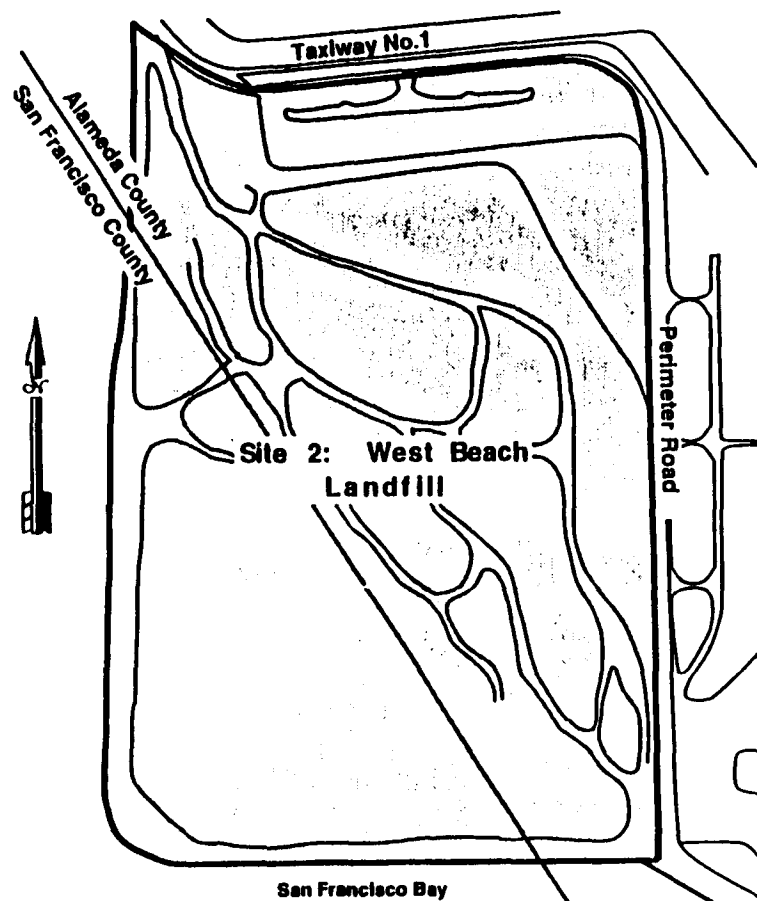
TABLE 3-1
Sites 2 Contaminants
Alameda NAS

VOC	Max. Conc.	Min. Conc.	Unit	Depth(ft) of Max. Conc.
Acetone	3.1 J	ND	mg/L	10
Benzene	0.013	ND	mg/L	*
Chlorobenzene	0.3	ND	mg/L	*
Chloroethane	0.0032	0.0011	mg/L	*
1,3-Dichlorobenzene	0.0014	ND	mg/L	*
1,4-Dichlorobenzene	0.4	ND	mg/L	10
Ethylbenzene	0.0071	ND	mg/kg	1
2,4-Dimethylphenol	0.0066	ND	mg/L	*

SVOC	Max. Conc.	Min. Conc.	Unit	Depth(ft) of Max. Conc.
Anthracene	0.1	ND	mg/kg	10
1,2-Benzanthracene	2.5	ND	mg/kg	0-0.5
Benzo(a)pyrene	5	ND	mg/kg	0-0.5
Benz(e)acephenanthrylene	8.3	ND	mg/kg	0-0.5
Benzo(g,h,i)perylene	4.8	ND	mg/kg	0-0.5
Benzo(k)fluoranthene	3.4	ND	mg/kg	0-0.5
Bis(2-ethylhexyl)phthalate	1.5	ND	mg/L	10
2-Chlorophenol	0.003	ND	mg/L	*
Chrysene	3.3	ND	mg/kg	0-0.5
p-Cresol	0.0032	ND	mg/L	*
Dibenzofuran	0.47	0.0018 mg/L	mg/kg	10
Dimethyl phthalate	0.47	ND	mg/L	*
2,4-Dinitrotoluene	0.18	ND	mg/kg	10
Fluorene	0.58	0.0012	mg/kg	10
Fluoroanthene	2.3	ND	mg/kg	0-0.5
Indeno(1,2,3-cd)pyrene	2.8	ND	mg/kg	0-0.5
2-Methylnaphthalene	2.1	ND	mg/kg	10
Naphthalene	2.4	ND	mg/kg	1
3-Nitroaniline	0.0227	ND	mg/L	*
N-Nitrosodiphenylamine	0.0017	ND	mg/L	0
Phenanthrene	3.6	0.073	mg/kg	1
Phenol	0.0089	ND	mg/L	*
Pyrene	2.7	ND	mg/kg	0-0.5

Pesticides	Max. Conc.	Min. Conc.	Unit	Depth(ft) of Max. Conc.
Aldrin	5.1E-05	ND	mg/L	*
Alpha-Chlordane	0.161J	ND	mg/kg	0
Aroclor-1248	0.33	ND	mg/kg	2
Aroclor-1260	0.4	ND	mg/kg	0-0.5
Chlordane	0.0295	ND	mg/kg	1
DDD	0.0735	0.000004	mg/kg	2
DDE	0.0228	ND	mg/kg	2
DDT	0.019	ND	mg/kg	0-0.5
Dieldrin	0.0186	0.00412	mg/kg	0
Heptachlor	0.0124J	ND	mg/kg	0





NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

SITES 2 AND 17 MAP
FIGURE 3-2

BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY

Figure 3-3

Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ALAMEDA

Contaminant (Synonym) [C A S Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Acetone (Dimethyl Ketone) <chem>(CH3)2CO</chem> [67-64-1]	Clear, colorless liquid with a fragrant sweet odor.	MW: 58.08 BP: 56 °C (133 °F) MP: -95 °C (-139 °F) VP: 181 mm Hg Sol: Miscible FP: -18 °C (0 °F) LEL: 2.6% UEL: 13.0% IP: 9.69 eV	Halogen acids and compounds, strong bases, caustics, strong oxidizing agents, amines and ammonia, chlorine and compounds, strong acids (esp. sulfuric, nitric, hydrochloric).	Site 1, 2, 3, 7A, 7C, 11, & 12 Maximum Concen- tration at Site: 7A @ 1,100 ug/kg	Respiratory system, skin, eye, CNS.	Skin, eyes, nose, and throat irritation; nausea, eye damage, vomiting, headache, or loss of consciousness;
Benzene <chem>C6H6</chem> [71-43-2]	Colorless to light yellow liquid with aromatic odor.	MW: 78.11 BP: 80 °C (176 °F) MP: 6 °C (42 °F) VP: 75 mm Hg Sol: 0.07% FP: -11 °C (-12 °F) LEL: 1.3% UEL: 7.1% IP: 9.25 eV	Chlorine, bromine with iron; strong oxidizers.	Site 1, 2, 7A, 7H, 7C, 10B, & 13 Maximum Concen- tration at Site: 7A @ 3,700 ug/L	Blood, bone marrow, eyes, skin, respiratory system, CNS.	Irritation of eyes, nose respiratory system; headache, nausea, dizziness; fatigue, anorexia; dermatitis; abdominal pain, pain, bone marrow, depression Leukemia
Chlorobenzene (Phenyl chloride) <chem>C6H5Cl</chem> [108-90-7]	Colorless liquid with a mothball- like odor.	MW: 112.56 BP: 131 °C (270 °F) MP: -45 °C (-50 °F) VP: 9 mm Hg Sol: 0.05% FP: 28 °C (82 °F) LEL: 1.3% UEL: 9.6% IP: 9.07 eV	Strong oxidizers.	Site 1, 2, & 4 Maximum Concen- tration at Site: 4 @ 3,200 ug/kg	Respiratory system, eyes, skin, nasal cavities, liver, CNS.	Incoherence, inebriation, abdominal cramp, cardiac arrhythmia, cardiac arrest, liver and kidney damage.
Chloroethane (Ethyl chloride) <chem>CH3CH2Cl</chem> [75-00-3]	Colorless Gas with a strong ether like odor	MW: 64.52 BP: 12 °C (56 °F) MP: -139 °C (-218 °F) VP: 1000 mm Hg Sol: 0.6% FP: -50 °C (-58 °F) LEL: 3.8% UEL: 15.4% IP: 10.97 eV	Strong oxidizers, Alkaline metals.	Site 2 & 5 Maximum Concen- tration at Site: 5 @ 130 ug/L	Reproductive system, CNS, CVS, liver, kidneys, respiratory system.	Abdominal cramp, vomiting, headache, cough, inebriation, incoordination, dizziness.

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Chloroform (Trichloromethane) <chem>ClC(Cl)Cl</chem> [67-66-3]	Clear, colorless liquid with pleasant, sweet odor.	MW: 119.38 BP: 61 °C (142 °F) MP: -64 °C (-83 °F) VP: 159 mm Hg Sol: 0.5% by vol @25°C FP: N/A LEL: N/A UEL: N/A IP: 11.42 eV	Strong bases, alkali metals, aluminum, magnesium, strong oxidizers.	Site 1,4,6,8, & 10A Maximum Concen- tration at Site: 10A @ 52 ug/L.	Liver, kidneys, heart, eyes, skin, CNS.	Headache, nausea, vomiting, dizziness; eye and skin irritation; dermatitis, Confusion, enlarged liver.
Chloromethane (Methyl Chloride) <chem>ClCCl</chem> [74-87-3]	Colorless gas with faint sweet odor	MW: 50.5 BP: -24 °C (-12°F) MP: -97 °C (-144°F) VP: 5 atm Sol: 0.5% FP: NA LEL: 8.1% UEL: 17.4% IP: 11.28 eV	Strong oxidizers, galvanized iron.	Site 1 Maximum Concen- tration at Site: 1 @ 3 ug/L.	Lungs, kidneys, liver, heart, CNS, Reproductive sys.	irritation of eyes, skin, mucous membranes, upper respiratory tract, dizziness, headache, confusion, weakness, nausea, vomiting, tremors, and nervousness
1,2-Dibromoethane (Ethylene Dibromide) <chem>BrCCBr</chem> [106-93-4]	Heavy, colorless to brown liquid with sweet odor (or solid below 50 °F)	MW: 187.8 BP: 131 °C (268°F) MP: 10 °C (50°F) VP: 11.7 mm Hg @25°C Sol: 0.40% FP: NA LEL: NA UEL: NA IP: 9.45 eV	Alkali metals, oxidizing agents, aluminum, magnesium, may decompose on exposure to light.	Site 7A Maximum Concen- tration at Site: 7A @ 14 ug/kg	Liver, kidneys, Lungs, eyes, respiratory sys, reproductive sys, skin	Burning sensation; coughing; wheezing; laryngitis; shortness of breath; somnolence; headache; nausea, vomiting; blistering with skin contact.
1,1-Dichloroethane (Ethylidene Chloride) <chem>ClCClC</chem> [75-34-3]	Colorless liquid with a chloroform-like odor.	MW: 98.97 BP: 57°C (135 °F) MP: -97°C (-143 °F) VP: 182 mm Hg Sol: 0.60% FP: -17°C (2 °F) LEL: 5.4% UEL: 11.4% IP: 11.06 eV	Strong oxidizers, caustics, strong alkalis	Site 4,5,6,8,9,10A, 11,16, & 19 Maximum Concen- tration at Site: 5 @ 350 ug/L.	Liver, kidneys, skin, lungs, CNS.	Skin irritation; CNS depression; liver and kidney damage; (drowsiness, loss of consciousness);

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
1,2-Dichloroethane (Ethylene Dichloride) ClCH ₂ CH ₂ Cl [107-06-2]	Colorless oily liquid with chloroform like odor	MW: 98.96 BP: 83 °C (182°F) MP: -35 °C (-31°F) VP: 64 mm Hg Sol: 0.9% FP: 13 °C (56 °F) LEL: 6.2% UEL: 16.0% IP: 11.05 eV	Oxidizing agents, aluminum, caustics, liquid ammonia	Site 7C Maximum Concen- tration at Site: 7A @ 7.26 ug/kg	Liver, kidneys, eyes, skin, CNS, CVS.	Irritation of eyes, skin, and respiratory system; CNS depression; nausea, headache, vomiting; damage to liver, kidneys
1,1-Dichloroethene (Vinylidene Chloride) C ₂ H ₂ Cl ₂ [75-35-4]	Liquid with mild, sweet chloroform like odor	MW: 96.95 BP: 32 °C (89°F) MP: -123 °C (-189°F) VP: 500 mm Hg Sol: 0.04% FP: -19 °C (-2 °F) LEL: 6.5% UEL: 15.5% IP: 10.00 eV	Oxidizing agents, air sensitive, moisture sensitive, copper, aluminum and their alloys, peroxides	Site 1,4,5,8,9,10A, 11, & 14 Maximum Concen- tration at Site: 5 @ 350 ug/L	Liver, kidneys, cardiovascular system, gastro- intestinal, blood, CNS, respiratory sys.	Irritating to eyes, respiratory system, and skin; damage to kidneys and liver.
1,2-Dichloroethene (Acetylene Dichloride) ClCH=CHCl [540-59-0]	Colorless liquid with an ether- like acid odor.	MW: 97.0 BP: 48-60°C (118-140 °F) MP: -49 to -82°C (-56 to -115 °F) VP: 180-265 mm Hg Sol: 0.4% FP: 2-4°C (36-39 °F) LEL: 5.6% UEL: 12.8% IP: 9.65 eV	Strong oxidizers, bases	Site 4,5,6,7B,8,12,13, 16, & 19 Maximum Concen- tration at Site: 5 @ 160 mg/kg	Liver, kidneys, eyes, CNS, respiratory sys.	Irritation of eyes, skin, and respiratory system; narcotic effect; CNS depression
1,2-Dichloropropane (Propylene Dichloride) CH ₃ CHClCH ₂ Cl [78-87-5]	Colorless liquid with chloroform like odor	MW: 112.99 BP: 97 °C (206°F) MP: -101 °C (-149°F) VP: 40 mm Hg @ 20°C Sol: 0.30% FP: 20 °C LEL: 3.40% UEL: 14.50% IP: 10.86 eV	Oxidizing agents, acids, bases, aluminum and its alloys.	Site 10A Maximum Concen- tration at Site: 10A @ 1.4 ug/L	Liver, kidneys, heart, blood, CNS, eyes, skin, respiratory sys.	Irritation of eyes, skin, and respiratory system; CNS depression; nausea, headache, vomiting; damage to liver, kidneys

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
2,4-Dimethylphenol (Xylenol) C ₈ H ₁₀ O [100-71-6]	Colorless liquid	MW: 122.16 BP: 211 °C MP: 26 °C VP: Sol: Slightly FP: LEL: UEL: IP:	Bases, acid chlorides, acid anhydrides, oxidizing agents, corrodes steel, brass, copper, copper alloys.	Site 1,2,5,7C, & 16 Maximum Concentration at Site: 16 @ 1,100 ug/kg	Skin, eyes, respiratory system.	Destructive to tissue of skin, eyes, and respiratory tract; burning sensation; coughing; wheezing; laryngitis, short- ness of breath; headache; nausea; vomiting.
Methylene Chloride (Dichloromethane) C ₂ H ₂ Cl ₂ [75-09-2]	Colorless liquid with a chloroform- like odor	MW: 84.94 BP: 40 °C (104°F) MP: -95 °C (-139°F) VP: 350 mm Hg Sol: 2% FP: N/A LEL: 11% UEL: 23% IP: 11.32 eV	Strong oxidizers, caustics, chemically active metals such as aluminum, magnesium, potassium, and sodium, concentrated nitric acid.	Site 4,10B, & 13 Maximum Concentration at Site: 10B @ 1,800 ug/kg	Skin, CNS, eyes, cardiovascular system.	headache; nausea; vomiting; dizziness; narcosis; low blood pressure; suffocation; CNS depression; severe respiratory irritation; skin, eye irritation; dermatitis, corneal damage.
Methyl Ethyl Ketone (2-Butanol) C ₄ H ₁₀ O [78-93-3]	Flammable clear colorless liquid with fragrant mint-like odor	MW: 72.1 BP: 79 °C (175°F) MP: -86 °C (-123°F) VP: 78 mm Hg Sol: 28% FP: -9 °C (16°F) LEL: 1.4% @ 93°F UEL: 11.4% @ 93°F IP: 9.54 eV	strong oxidizing agents, strong bases, caustics, mineral acids, amines, ammonia, halogens	Site 1,4,13, & 14 Maximum Concentration at Site: 1 @ 3.6 ug/L	Eye, skin, CNS, respiratory sys.	drowsiness; irritation of respiratory tract; loss of consciousness; dermatitis; nausea; vomiting; headache; dizziness.
4-Methyl-2-pentanone (Isopropylacetone) (Hexone) C ₆ H ₁₂ O [108-10-1]	Colorless liquid, with a pleasant odor	MW: 100.16 BP: 117 °C (242°F) MP: -84 °C (-120°F) VP: 15 mm Hg @ 20 °C Sol: 1.91% FP: 18 °C (64 °F) LEL: 1.20% UEL: 8.00% IP: 9.3 eV	Oxidizing agents, reducing agents, strong bases.	Site 7C Maximum Concentration at Site: 7C @ 72 ug/kg	CNS, liver, eyes, kidneys, skin, respiratory sys.	Irritation of eyes, skin, respiratory system, mucous membranes; headaches; narcosis; coma; dermatitis.

Figure 3-3
(continued)

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Toluene (Methyl benzene) C ₆ H ₅ CH ₃ [108-88-3]	Colorless liquid with an sweet pungent odor	MW: 92 BP: 111°C (231°F) MP: -95°C (-139°F) VP: 21 mm Hg Sol: 0.07% FP: 4°C (40°F) LEL: 1.1% UEL: 7.1% IP: 8.82 eV	Strong oxidizers.	Site 1,3,4,5,7A,7C, 8,9,10B,13,14,16, & 19 Maximum Concen- tration at Site: 7C @ 39 mg/kg	Skin, liver, kidneys, CNS, eyes, respiratory sys.	Dermatitis; weakness; fatigue; dizziness; euphoria; dilated pupils; photophobia; eye and nose irritation; insomnia
1,1,1-Trichloromethane (Methyl chloroform, TCA) CH ₃ CCl ₃ [71-55-6]	Colorless liquid with a mild chloroform-like odor.	MW: 133.41 BP: 74°C (165°F) MP: -31°C (-23°F) VP: 100 mm Hg Sol: 0.4% FP: N/A LEL: 7.5% UEL: 12.5% IP: 11.00 eV	Strong caustics, strong oxidizers, chemically active metals (aluminum, magnesium powder, sodium, potassium).	Site 4,5,8, & 19 Maximum Concen- tration at Site: 5 @ 1,700 mg/kg	Skin, CNS, eyes, cardio- vascular system, liver.	Eye irritation; dermatitis; headache; lassitude; CNS depression; irregular heartbeat
Trichloroethylene (Trichloroethene, TCE) C ₂ Cl ₂ =CCl ₂ [79-01-6]	Colorless liquid with a sweet odor like chloroform.	MW: 131 BP: 87°C (189°F) MP: -73°C (-99°F) VP: 58 mm Hg Sol: 0.14% FP: NA LEL: 8.0% UEL: 10.5% IP: 9.45 eV	Strong caustics; when acidic, reacts with aluminum; chemically active metals (barium, lithium, sodium, magnesium, titanium).	Site 1,4,5,6,7C,8, 10A,11,16, & 19 Maximum Concen- tration at Site: 5 @ 110 mg/kg	Skin, eyes, respiratory system, heart, liver, kidneys, skin, CNS.	Irritation of eyes; vomiting; dermatitis; headache; vertigo; blurred vision; nausea; tremors; loss of feeling in extremities; skin irritation; giddiness.
Vinyl Chloride (Chloroethylene) CH ₂ =CHCl [75-01-4]	Colorless gas.	MW: 62.5 BP: -14°C (7°F) MP: -160°C (-256°F) VP: 3.3 atm Sol: 0.1% FP: NA LEL: 3.60% UEL: 33.00% IP: 9.995 eV	Copper, oxidizing materials.	Site 1,4,5,6,7B,8, & 11 Maximum Concen- tration at Site: 5 @ 20 mg/kg	Liver, blood, respiratory system, CNS, lymphatic system.	Weakness; abdominal pain; gastrointestinal bleeding; pallor or blueness of extremities.

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Xylene C ₆ H ₄ (CH ₃) ₂ [95-47-6] o-Xylene [108-38-3] m-Xylene [106-42-3] p-Xylene	Colorless liquid with an aromatic odor.	MW: 106 BP: 144°C (292°F) MP: -48 to +12°C (-54 to +56°F) VP: 7 mm Hg @ 20°C Sol: 0.02% FP: 27-32°C (81-90°F) LEL: 1-1.1% UEL: 6-7% IP: 8.44-8.56 eV	Strong oxidizers, strong acids	Site 1,4,5,6,7A,7B, 7C,8,9,10B,13,14, & 19 Maximum Concen- tration at Site: 7C @ 97 mg/kg	Eyes, skin, gastro- intestinal tract, blood, liver, CNS, kidneys, respiratory sys.	Eyes, nose and throat irritation; nausea; dermatitis; corneal lesions; dizziness; poor equilibrium; anorexia; vomiting; abdominal pain; excitement.

**Figure 3-3
(continued)**

**Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ALAMEDA**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Anthracene C14 H10	Off-white to pale green-yellow crystals with bluish fluorescence	MW: 178.24 BP: 342 °C (648 °F) MP: 214 °C (417 °F) VP: N/A Sol: Insol FP: 121 °C (250 °F) LEL: 0.60% UEL: N/A IP:	Strong oxidizing agents, fluorine.	Site 1,2,4,5,6,7A,7C, 8,9,11,12,13,16 & 19 Maximum Concen- tration at Site: 8 @ 37 mg/kg	None	Dust may irritate eyes, nose, throat, or lungs.
1,2-Benzanthracene (Benzo(a)anthracene) C18 H12 [56-55-3]	Light yellow to tan powder.	MW: 228.28 BP: 438 °C (820 °F) MP: 157-159 °C (315-318 °F) VP: Sol: Insol FP: LEL: UEL: IP:	Strong oxidizers.	Site 1,2,4,5,6,7A,7B, 7C,8,9,11,12,13, 16, & 19 Maximum Concen- tration at Site: 1 @ 57 mg/kg	Kidney, ureter, bladder, skin and appendages.	Fatal; irritation
Benzo(a)pyrene (Benzo(d,e,f)chrysene) C20 H12 [50-32-8]	Yellow-green powder.	MW: BP: 495 °C (923 °F) MP: 177-180 °C (351-356 °F) VP: Sol: FP: LEL: UEL: IP:	Oxidizer agents.	Site 1,2,4,5,6,7A,7B, 7C,8,9,10A,11,12, 13,16, & 19 Maximum Concen- tration at Site: 1 @ 81 mg/kg	Skin, lungs.	Irritation of eyes and skin.
Benzo(c)acephenanthrylene (Benzo(b)fluoranthene)	Off-white fiber.	MW: BP: MP: 163-165 °C (325-329 °F) VP: Sol: FP: LEL: UEL: IP:	Strong oxidizers.	Site 1,2,4,5,6,7A,7B, 7C,8,9,11,12,13 16, & 19 Maximum Concen- tration at Site: 1 @ 59 mg/kg	Lungs, thorax; kidney, ureter, bladder; skin, appendages.	Irritation.

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Benzo(g,h,i)perylene	Yellow crystalline powder.	MW: BP: >500 °C (932 °F) MP: 277-279 °C (531-534 °F) VP: Sol: FP: LEL: UEL: IP:	Strong oxidizers.	Site 1,2,4,5,6,7A,7B, 7C,10A,11,12,13, 16, & 19 Maximum Concen- tration at Site: 1 @ 82 mg/kg		Irritation of eyes, skin.
Benzo(k)fluoranthene	Yellow powder.	MW: BP: MP: 215-217 °C (419-423 °F) VP: Sol: FP: LEL: UEL: IP:	Strong oxidizers	Site 1,2,4,5,6,7A,7B, 7C,8,9,10A,11,12, 13,16, & 19 Maximum Concen- tration at Site: 1 @ 56 mg/kg	Lungs, thorax.	Irritation of eyes and skin.
Benzoic acid C7 H6 O2 [65-85-0]		MW: 122.12 BP: 249 °C (480 °F) MP: 122 °C (252 °F) VP: < 1 mm Hg Sol: Slight FP: 121 °C (250 °F) LEL: N/A UEL: N/A IP:	Strong oxidizers, alkalies.	Site 7A Maximum Concen- tration at Site: 7A @ 18.4 ug/kg	None	Irritation of eyes, skin, mucous membranes.
Bis(2-chloroisopropyl)ether		MW: BP: MP: VP: Sol: FP: LEL: UEL: IP:		Site 1,10A, & 12 Maximum Concen- tration at Site: 10A @ 31 ug/L		

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Bis(2-ethylhexyl)phthalate C24 H38 O4 [117-81-7]	light colored oily almost odorless liquid	MW: 390.54 BP: 384 °C (723°F) MP: -50 °C (-58°F) VP: Sol: FP: 207 °C (405 °F) LEL: 0.30% UEL: IP:	Oxidizing agents.	Site 1,2,4,5,7A,8, 10A,11,12,16, & 19 Maximum Concen- tration at Site: 4 @ 22 mg/kg	Liver, gastro- intestinal.	Irritation of eyes, skin respiratory system
Carbon disulfide C S2 [75-15-0]	colorless to faintly yellow liquid with a strong disagreeable odor	MW: 76.14 BP: 45 °C (115 °F) MP: -112 °C (-170 °F) VP: 300 mm Hg Sol: .294% @ 20 °C FP: -30 °C (-22 °F) LEL: 1.00% UEL: 50.00% IP: 10.08 eV	Strong oxidizers, azides, zinc, aluminum, sodium metals, potassium metals, amines, oxides of nitrogen, metals, chlorines, fluorine, hypochlorite	Site 4,7A, & 8 Maximum Concen- tration at Site: 7A @ 150 ug/kg	CNS, PNS, eyes, skin, liver, cardio- vascular system, kidneys, reproductive sys.	Irritation of skin, eyes, mucous membranes; head- ache, nausea, vomiting, dizziness, gastrointestinal irritation; disturbance of cardiac rhythm.
2-Chloroethyl Ether (Bis(2-chloroethyl)ether) C4 H8 Cl2 O	Colorless clear liquid with pungent odor	MW: 143.02 BP: 178 °C (352°F) MP: -50 °C (-58°F) VP: 4 mm Hg @ 20°C Sol: Insol FP: 54 °C (129°F) LEL: UEL: IP:	Oxidizing agents.	Site 1,5,10A, & 12 Maximum Concen- tration at Site: 10A @ 86 ug/L	Gastro- intestinal. Sense organs	irritating to skin, eyes, mucous membrane; diarrhea
4-Chloro-3-methylphenol (4-Chloro-m-Cresol) C7 H7 Cl O [59-50-7]	White crystals with Phenolic Odor	MW: 142.5 BP: 235 °C (455°F) MP: 65 -68 °C (149-154°F) VP: Sol: 4 gm/l FP: LEL: UEL: IP:	Bases, acid chlorides, acid anhydrides, oxidizing agents, corrodes steel, brass, copper and copper alloys.	Site 1,7A, & 9 Maximum Concen- tration at Site: 9 @ 43 ug/kg	Eyes.	Irritation of eyes, skin, respiratory system; tremors; somnolence; coma

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
2 Chlorophenol (Chlorophenol) C6 H5 Cl O	Colorless liquid	MW: 128.5 BP: varies MP: VP: Sol: FP: 63 °C LEL: UEL: IP:	Acid Chlorides, acid anhydrides, oxidizing agents.	Site 2 & 7A Maximum Concentration at Site: 2 @ 3 ug/L	Liver, kidneys	Destructive to tissue of skin, eyes, and respiratory tract; burning sensation; coughing; wheezing; laryngitis; shortness of breath; headache; nausea; vomiting
Chrysene (Benzo(a)phenanthrene) C18 H12 [218-01-9]	White solid	MW: 228.28 BP: 448 °C (838°F) MP: 252-254 °C (486-489°F) VP: Negligible Sol: Negligible FP: N/A LEL: UEL: IP:	Strong oxidizers.	Site 1,2,4,5,6,7A,7B, 7C,8,9,10A,11,12, 13,14,16, & 19 Maximum Concentration at Site: 1 @ 72 mg/kg	Skin, appendages.	Irritation.
1,2,5,6 Dibenzoanthracene (Dibenzoanthracene) C22 H14 [53-70-3]	Light-yellow crystalline powder	MW: 278.33 BP: 524 °C (975°F) MP: 266 °C (511°F) VP: Sol: Insol FP: LEL: UEL: IP:	Strong Oxidizing agents	Site 1,5,8,9,11,12, & 16 Maximum Concentration at Site: 1 @ 21 mg/kg	Liver, lungs, kidneys,urcter, bladder, skin, appendages.	Irritation.
Dibenzofuran C12 H8 O	White Crystalline Powder	MW: 168 BP: 285 °C (545°F) MP: 83-85 °C (181-185°F) VP: Sol: FP: LEL: UEL: IP:	Strong oxidizers.	Site 2,4, & 5 Maximum Concentration at Site: 2 @ 470 ug/kg		Irritation.

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Dibutyl phthalate (Di-n-butylphthalate) C6H4(COOC4H9)2 [84-74-2]	Colorless oily liquid with a slight aromatic odor	MW: 278.3 BP: 340 °C (644°F) MP: -35 °C (-31°F) VP: 0.00007 mm Hg Sol: 0.001% FP: 157°C (315°F) LEL: 0.47% UEL: NA IP: NA	Oxidizing agents, acids, nitrates, liquid chlorine, nitrates, alkalis	Site 1, 7C, 8, 10B, 12, 16, & 19 Maximum Concen- tration at Site: 1 @ 13 mg/kg	Kidneys, CNS, ureter, bladder, gastrointestinal, eyes, male reproductive system, respiratory sys.	Irritation of eyes, mucous membranes, upper respiratory tract; nausea; vomiting; dizziness; headache; hallucinations
1,2-Dichlorobenzene (o-Dichlorobenzene) C6H4Cl2 [95-50-1]	Colorless to pale yellow liquid with a pleasant aromatic odor.	MW: 147.01 BP: 180 °C (357°F) MP: -17 °C (1°F) VP: 1.2 mm Hg Sol: 0.011% FP: 66°C (151 °F) LEL: 2.20% UEL: 9.20% IP: 9.06 eV	Strong oxidizers; aluminum or aluminum alloys; sensitive to light, chlorides, acids	Site 1, 4, & 7A Maximum Concen- tration at Site: 7A @ 420 ug/kg	CNS, liver, kidneys, blood, eyes, skin, respiratory sys.	Eye, skin, and respiratory tract irritation; blisters; liver and kidney damage; CNS depression
1,3-Dichlorobenzene (m-Dichlorobenzene) C6H4Cl2 [451-73-1]	Colorless liquid	MW: 147.0 BP: 172 °C (342°F) MP: -24 °C (-11°F) VP: 5 mm Hg Sol: Insol FP: 63 °C (146 °F) LEL: UEL: IP:	Strong oxidizers; aluminum or aluminum alloys.	Site 2, 5, 16, & 19 Maximum Concen- tration at Site: 19 @ 590 ug/kg	liver, kidney and blood	Eye, skin, and respiratory tract irritation; dizziness; lightheadedness
1,4-Dichlorobenzene (p-Dichlorobenzene) C6H4Cl2 [106-46-7]	Colorless or white crystalline solid with a moth-ball like odor	MW: 147.0 BP: 174 °C (345°F) MP: 53 °C (128°F) VP: 1.3 mm Hg Sol: 0.008% FP: 66 °C (150 °F) LEL: 2.50% UEL: N/A IP: 8.98 eV	Strong oxidizers such as chlorine or perman- ganate	Site 1, 2, 4, & 5 Maximum Concen- tration at Site: 2 @ 400 ug/L	Liver, respiratory system, eyes, kidneys, skin	Eye irritation; swelling around the eye; profuse rhinorea; headaches; anorexia; nausea; vomiting; low weight; jaundice; cirrhosis.

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Diethyl phthalate (Ethyl phthalate) C ₆ H ₄ (C ₂ H ₅ COO) ₂ [84-66-2]	Colorless, practically odorless, oily liquid with bitter taste and a very slight aromatic odor.	MW: 222.24 BP: 295 °C (563 °F) MP: -40 °C (-47 °F) VP: 1 mm Hg Sol: 0.1% FP: 161 °C (322 °F) LEL: 0.07% UEL: N/A IP: N/A	Strong oxidizers, strong acids, nitric acid, alkalis, water	Site 1 & 19 Maximum Concen- tration at Site: 19 @ 12 mg/kg	CNS, PNS, reproductive sys respiratory sys, eyes, skin.	Irritation of eyes, skin, mucous membranes; headaches, dizziness, spasms in arms and legs.
Dimethyl phthalate (Methyl phthalate) C ₆ H ₄ (C ₂ H ₅ COO) ₂ [131-11-3]	Colorless oily liquid with slightly sweet odor.	MW: 194.19 BP: 284 °C (543 °F) MP: 6 °C (42 °F) VP: 0.01 mm Hg Sol: 0.4% FP: 146 °C (295 °F) LEL: 0.94% UEL: NA IP: 9.64 eV	Strong oxidizers, strong acids, strong bases, nitrates	Site 2 & 7A Maximum Concen- tration at Site: 2 @ 470 ug/kg	Respiratory system, gastro- intestinal tract, eyes	Irritation of eyes, skin, mucous membranes; cough; difficult breathing; vomiting; narcosis; nausea; headache; dizziness; gastro-intestinal irritation; CNS depression.
2,4-Dinitrotoluene C ₆ H ₃ (NO ₂) ₂ [25321-14-6]	Orange-yellow crystals with characteristic odor	MW: 182 BP: 300 °C (572 °F) MP: 70 °C (158 °F) VP: 1 mm Hg @ 100 °C Sol: Insol FP: 207 °C (404 °F) LEL: NA UEL: NA IP: NA	Oxidizing agents, reducing agents, strong bases	Site 2 & 7A Maximum Concen- tration at Site: 2 @ 180 ug/kg	Blood, liver, spleen, CVS, reproductive sys	Burning sensation; anemia; coughing; wheezing; jaundice; laryngitis; shortness of breath; headache, nausea, and vomiting.
Ethylbenzene C ₆ H ₅ CH ₃ C ₆ H ₅ [100-41-4]	Colorless liquid with aromatic odor.	MW: 106 BP: 136 °C (277 °F) MP: -95 °C (-139 °F) VP: 7 mm Hg Sol: 0.01% FP: 13 °C (55 °F) LEL: 0.8% UEL: 6.7% IP: 8.76 eV	Strong oxidizers.	Site 1,2,4,5,7A,7C,8, 9,10B,13,14, & 19 Maximum Concen- tration at Site: 7C @ 52 mg/kg	Eyes, skin, upper respiratory system, CNS.	Irritation of eyes, mucous membranes; dermatitis; headache, narcosis, coma

Figure 3-3
(continued)

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Fluoranthene C16H10	Yellow to Tan Crystals	MW: 202 BP: 301°C (573°F) MP: 102-110°C (225-230°F) VP: Sol: FP: LEL: UEL: IP:	Strong oxidizers	Site 1,2,4,5,6,7A,7B, 7C,8,10A,11,12,13, 14,16, & 19 Maximum Concen- tration at Site: 8 to 160 mg/kg	Skin and Appendages	
Indeno[1,2,3-cd]pyrene		MW: BP: MP: VP: Sol: FP: LEL: UEL: IP:		Site 1,2,4,5,6,7A,7B, 7C,8,9,11,12,13, 16, & 19 Maximum Concen- tration at Site: 8 to 40 mg/kg		
2-Methylnaphthalene (Beta-Methylnaphthalene)	White crystals	MW: 142.2 BP: 242°C (468°F) MP: 31°C (91°F) VP: Negligible Sol: Negligible FP: N/A LEL: N/A UEL: N/A IP: 7.95 eV	Strong oxidizers	Site 1,2,4,6,7A,7C, 8,9,10B,11,12,13, & 16 Maximum Concen- tration at Site: 10B to 41 ug/kg		
2-Methylphenol (o-Cresol) C7H8O [95-48-7]	White crystalline solid with a sweet fatty odor	MW: 108.2 BP: 191°C (376°F) MP: 31°C (88°F) VP: 0.3 mm Hg Sol: 2% FP: 89°C (178°F) LEL: 1.47% UEL: IP: 8.93 eV	Oxidizing agents, acids, light and air sensitive	Site 1,4, & 7A Maximum Concen- tration at Site: 1 to 2.8 ug/l.	CNS, lungs, liver, kidneys, CVS, pancreas, respiratory sys, eyes, skin	Destructive to tissue of skin, eyes, and respiratory tract; wheezing; burning sensation; laryngitis; shortness of breath; headache; coughing; nausea, vomiting; damage to eyes, kidneys

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
1-Methylphenol (p-Cresol) <chem>CC1=CC=C(O)C=C1</chem> [106-44-5]	Crystalline solid with sweet tarry odor	MW: 108 BP: 202 °C (396 °F) MP: 35 °C (95 °F) VP: 0.11 mm Hg @ 25 °C Sol: 2% TP: 86 °C (189 °F) LEL: 1.1% UEL: NA IP: 8.97 eV	Oxidizing agents, acids	Site 2, 4, & 7A Maximum Concentration at Site: 7A @ 470 ug/kg	CNS, lungs, liver, kidneys, eyes, skin, pancreas, CVS, respiratory sys	Destructive to tissue of skin, eyes, and respiratory tract; convulsions; ulcers; burning sensation; coughing; wheezing; laryngitis; shortness of breath; headache; nausea; vomiting; damage to eyes and kidney
Naphthalene <chem>C10H8</chem> [91-20-3]	Colorless to brown solid with an odor of mothballs	MW: 128.16 BP: 218 °C (424 °F) MP: 80 °C (176 °F) VP: 0.08 mm Hg Sol: 0.001% TP: 79 °C (174 °F) LEL: 0.9% UEL: 5.9% IP: 8.12 eV	Strong Oxidizers, Chronic Anhydride	Site 1,2,4,5,6,7A,7B, 7C,8,9,10B,11,12, 13,16, & 19 Maximum Concentration at Site: 8 @ 13 mg/kg	blood cells, liver, kidneys, eyes, CNS, skin	Eye irritation; excitement; headache; confusion; malaise; nausea; vomiting; abdominal pain; irritation to bladder; profuse sweating; jaundice; renal shutdown; dermatitis
1-Nitroaniline (m-Nitroaniline) <chem>C6H6N2O2</chem> [99-09-2]	Yellow powder	MW: 138 BP: 306 °C (583 °F) MP: 112-114 °C (233-235 °F) VP: 1 mm Hg Sol: TP: LEL: UEL: IP:	Acids, acid chlorides, acid anhydrides, chloroformates, strong oxidizing agents	Site 2 Maximum Concentration at Site: 2 @ 22.7 ug/l.	Blood	Irritation of eyes, skin, and respiratory system; cyanosis
N-Nitrosodiphenylamine <chem>C12H10N2O</chem>	solid green plates with bluish luster	MW: 198.22 BP: MP: 144 °C (291 °F) VP: Sol: Slightly TP: LEL: UEL: IP:	Oxidizing Agents	Site 2,4,5,7A,9,13, & 19 Maximum Concentration at Site: 5 @ 77 mg/kg	Bladder	Eye, skin, mucous membrane, upper respiratory tract irritation; headaches; poor appetite

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Figure 3-3
(continued)

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Pentachlorophenol C ₆ HCl ₅ O [87-86-5]	Colorless to white crystalline solid with a benzene like odor	MW: 266.55 BP: 309 °C (588°F) MP: 190 °C (374°F) VP: 0.0001 mm Hg Sol: 0.001% LP: N/A LEL: N/A UEL: N/A IP: N/A	Strong Oxidizers Acids, alkalis	Site 9, 13, & 19 Maximum Concentration at Site: 19 @ 1,600 ug/kg	Cardiovascular system, liver, eyes, respiratory system, skin, kidneys, and CNS	Heart failure; eye swelling; dermatitis; sneezing; coughing; eye, nose, throat irritation; dizziness, high fever.
Phenanthrene C ₁₄ H ₁₀ [85-01-8]	Monoclinic plates	MW: 178.22 BP: 340 °C (644°F) MP: 100 °C (212°F) VP: Insol Sol: Insol LP: N/A LEL: N/A UEL: N/A IP: N/A	Strong oxidizers	Site 1,2,4,5,6,7A,7B, 7C,8,9,11,12,13, 14,16, & 19 Maximum Concentration at Site: 8 @ 170 mg/kg	Skin and appendages	Dermatitis; bronchitis; eye and skin irritation; mucous membrane and upper respiratory tract irritation.
Phenol C ₆ H ₅ OH [108-95-2]	Colorless to light-pink solid or thick liquid with sweet tar like odor.	MW: 94.11 BP: 182 °C (359°F) MP: 43 °C (109°F) VP: 0.4 mm Hg Sol: 9% LP: 79 °C (175°F) LEL: 1.8% UEL: 8.6% IP: 8.50 eV	Strong oxidizers, acids, aluminum chloride, calcium hypochlorite	Site 2,4,7A,7C, & 9 Maximum Concentration at Site: 7C @ 300 ug/kg	Liver, kidney, skin, eyes, & respiratory sys.	Headache; coughing; difficulty breathing; chest pains; lung irritation; pulmonary edema; nausea; vomiting; gastrointestinal irritation; burns to mouth and throat.
Pyrene C ₁₆ H ₁₀ [129-00-0]	Monoclinic colorless prismatic tablets	MW: 202.24 BP: 304 °C (579°F) MP: 156 °C (313°F) VP: Insol Sol: Insol LP: N/A LEL: N/A UEL: N/A IP: N/A	Strong oxidizers	Site 1,2,3,4,5,6,7A, 7B,7C,8,9,10A,10B, 11,12,13,14,16, & 19 Maximum Concentration at Site: 8 @ 170 ug/kg	Liver, kidney, and blood.	excitement; spasticity

**Figure 3-3
(continued)**

Contaminant (Synonym) (C.A.S. Number)	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Tetrachloroethene (Perchloroethylene, PCE) <chem>ClC(Cl)(Cl)Cl</chem> (127-18-4)	Colorless liquid with an odor like ether or chloroform	MW: 166 BP: 121 °C (250 °F) MP: -19 °C (-8 °F) VP: 14 mm Hg Sol: 0.015% FP: N/A LEL: N/A UEL: N/A IP: 9.12 eV	Strong oxidizers, chemically active metals (barium, lithium, beryllium), caustic soda, sodium hydroxide, potash	Site 1, 5, 6, 9, & 19 Maximum Concen- tration at Site: 5 to 45 mg/kg	Eyes, upper respiratory system, liver, skin, kidneys, CNS	Irritation of eyes; nasal septum, throat; irritation of skin; ulceration; dizziness; gastrointestinal upset; headaches, somnolence, flush face
1,2,4-Trichlorobenzene <chem>ClC1=CC=C(Cl)C=C1</chem> (120-82-1)	Clear, nearly colorless liquid with aromatic odor	MW: 181.45 BP: 213 °C (415 °F) MP: 17 °C (63 °F) VP: 1 mm Hg Sol: 0.001% FP: 106 °C (222 °F) LEL: NA UEL: 6.60% IP: NA	Strong oxidizing agents, steam, acids	Site 7A Maximum Concen- tration at Site: 7A to 420 ug/kg	Eyes, skin, respiratory sys., liver, reprod sys., and kidney	Skin, eye, mucous membrane irritation; liver and kidney damage

**Figure 3-3
(continued)**

**Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ALAMEDA**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Diesel See Benzene, Toluene, Xylene and Benzotapyrene		MW: BP: MP: VP: Sol: FP: LEL: UEL: IP:		Site 4 & 14 Maximum Concen- tration at Site: 4 to 57,000 ug/kg		Headache; nausea; CNS; depression; anorexia; pulmonary edema; kidney and liver damage
JP-5 See Benzene		MW: BP: MP: VP: Sol: FP: LEL: UEL: IP:		Site 4, 5, 12, & 14 Maximum Concen- tration at Site: 14 to 11,000 mg/kg		Irritation of eye, nose, stomach, pulmonary edema
Kerosene (Coal Oil) [8008-20-6]	Colorless to yellowish, oily liquid with a strong characteristic odor	MW: approx 170 BP: 175-325 °C (347-617 °F) MP: -46 °C (-50 °F) VP: 5 mm Hg @ 38 °C Sol: Insol FP: 38-72 °C (100-162 °F) LEL: 0.70% UEL: 5.00% IP: N/A	Strong oxidizers, strong acids, strong bases, amines	Site 14 Maximum Concen- tration at Site: 14 to 350 mg/kg	Eyes, skin, CNS, respiratory sys.	Tremors; dyspnea; cyanosis; acute pulmonary edema; hallucinations; convulsions; coma; respiratory stimulation.
Motor Oil		MW: BP: MP: VP: Sol: FP: LEL: UEL: IP:		Site 4, 5, 8, 12, & 14 Maximum Concen- tration at Site: 5 to 5,200 mg/kg		Gastrointestinal irritation; pulm irritation.

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**Figure 3-3
(continued)**

Contaminant (Synonym) (C.A.S. Number)	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Oils & Grease		MW BP MP VP Sol TP LEL UEL IP		Site 1, 2, 6, 10B, 14, & 19 Maximum Concen- tration at Site: 1 to 11,000 mg/kg		

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**Figure 3-3
(continued)**

**Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ALAMEDA**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Antimony Sb [7440-36-0]	Silver white, hard, brittle, metal	MW: 121.75 BP: 1635 °C (2975 °F) MP: 630 °C (1166 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong oxidizing agents, strong acids, halogenated acids, chlorine, fluorine	Site 4,5,7A,10A, & 12 Maximum Concen- tration at Site: 4 to 12 mg/kg	Respiratory system, cardiovascular system, eyes, skin	Dermatitis; liver and kidney damage; coughing; wheezing; irritation to eyes, skin, nose throat, vomiting
Arsenic As [7440-38-2]	Gray Shiny Brittle Oxidizes to Black As ₂ O ₃	MW: 74.9 BP: Sublimates MP: 613 °C (1135 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Sodium metal, aluminum, strong bases, strong oxidizing agents, chemically active metals	Site 4,5,6,7A,7B,7C, 8,9,10A,10B,11,12, 13,14,15, & 19 Maximum Concen- tration at Site: 4 to 8.3 mg/kg	Liver, kidneys, skin, lungs, lymphatic sys, CNS, respiratory sys, reproductive sys, gastro- intestinal tract.	Skin, eyes, and respiratory system irritation; nausea; vomiting; paralysis; gastrointestinal irritation.
Barium Ba [7440-39-3]	Yellow white slightly lustrous lumps	MW: 137.3 BP: 1600 °C (2912 °F) MP: 710 °C (1310 °F) VP: Sol: FP: LEL: UEL: IP:	None	Site 3,4,5,6,7A,7B, 7C,8,9,10A,10B,11, 12,13,14,15, & 19 Maximum Concen- tration at Site: 7A to 2,520 mg/kg	None	Burn skin, eyes; Skin, eyes, nose, & throat irritation; coughing, difficulty breathing.
Beryllium Be [7440-41-7]	Hard, brittle, gray metal	MW: 9.01 BP: 2500 °C (4532 °F) MP: 1287 °C (2349 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP:	Sodium metal, aluminum, halogenated hydrocarbons Acids, caustics, chlorinated hydrocarbons.	Site 4,7A,13, & 19 Maximum Concen- tration at Site: 4 to 272 ug/l.	Lungs, skin, eyes, mucous membranes, respiratory sys.	Irritation of eyes, skin, nose and throat; cough; difficult breathing.

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Cadmium Cd [7440-43-9] - Metal [1306-19-0] as CdO	silvery white blue-tinged lustrous metal	MW: 112.4 BP: 765 °C (1409 °F) MP: 321 °C (610 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Oxidizing agents, acids, elemental sulfur, selenium, and tellurium.	Site 4,5,7A,8,10A, 12,14, & 19 Maximum Concen- tration at Site: 10A @ 440 mg/kg	Lung, kidneys, uterus, prostate, bladder, blood, musculo skeletal sys, respiratory sys.	Pulmonary edema; coughing; dyspnea, tight chest; proteinuria; mild anemia; substernal pain; anorexia; headache; chills; diarrhea; muscle aches; emphysema; nausea; vomiting
Chromium Cr [7440-47-3]	Steel gray lustrous metal	MW: 52 BP: 2642 °C (4788 °F) MP: 1900 °C (3452 °F) VP: 0 mm Hg Sol: Slight FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong oxidizers and alkalis	Site 3,4,5,7C,8,9, 10A,10B, 12,13,14, 16, & 19 Maximum Concen- tration at Site: 4 @ 1,430 mg/kg	Respiratory system, eyes, skin	Fibrosis of lungs; dermatitis; eye and skin irritation
Cobalt Co [7440-48-4]	Gray, hard, magnetic, ductile metal	MW: 58.93 BP: 3100 °C (5612 °F) MP: 1493 °C (2719 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong oxidizers, Ammonium Nitrate	Site 3,4,5,7A,7C,9 10B,11,14,16, & 19 Maximum Concen- tration at Site: 4 @ 32.5 mg/kg	Eyes, kidneys, skin, respiratory sys.	Irritation of eyes, skin, mucous membrane, somnolence coughing, dyspepsia, dermatitis.
Copper Cu [7440-50-8] as Metal [1317-38-0] as CuO	red lustrous ductile metal. Green carbonate oxidation product.	MW: 63.55 BP: 2595 °C (4703 °F) MP: 1083 °C (1981 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong acids, active halogen compounds, chlorine, strong oxidizers.	Site 3,4,5,6,7A,7B, 7C,8,9,10A,10B,11, 12,13,14,15,16, & 19 Maximum Concen- tration at Site: 7A @ 3,520 mg/kg	Eyes, skin, respiratory sys, liver, & kidneys.	Irritation of eyes and skin; cough; sneezing; dermatitis; nausea; vomiting; headache; dizziness; gastro- intestinal irritation.

**Figure 3-3
(continued)**

Contaminant (Synonym) (C.A.S. Number)	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Lead Pb [7440-92-1]	Bluish White silvery gray metal	MW: 207.2 BP: 1740 °C (3164 °F) MP: 327 °C (621 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong oxidizers, hydrogen peroxide, active metals (sodium, potassium)	Site 4,5,7A,7B,7C,9, 10A,10B,11,12,13,14, 15,16, & 19 Maximum Concen- tration at Site: 7A @ 6,760 mg/kg	Kidneys, liver, blood, gastro- intestinal tract, CNS, eyes, gingival tissue	Pallor; blue gums, anemia; abdominal pain, weight loss; lethargy; colic, constipation
Manganese Mn [7440-96-5]	silvery white metal	MW: 54.93 BP: 1961 °C (3561 °F) MP: 1244 °C (2251 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Acids, bases, moisture, halogens, sulfur oxides oxidizers	Site 3,4,7C,9,10B,13, 16, & 19 Maximum Concen- tration at Site: 13 @ 12 mg/L	Nerves, lung liver, kidney respiratory sys, CNS, blood	poor appetite; weakness; sleepiness; changes in speech, balance and personality; insomnia; dry throat, coughing, flu like fever
Mercury Hg [7440-97-6]	silvery white, heavy, mobile liquid metal	MW: 200.59 BP: 357 °C (675 °F) MP: -39 °C (-38 °F) VP: 2E-3 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong Oxidizers	Site 4,5,7A,8,10A, & 12 Maximum Concen- tration at Site: 7A @ 2.29 mg/kg	kidneys, eyes, skin, CNS, PNS, respiratory sys.	pain; shortness of breath; pulmonary edema, tremor; gastrointestinal distress; insomnia
Nickel Ni [7440-02-0]	Silvery white metal	MW: 58.69 BP: 2847 °C (5139 °F) MP: 1555 °C (2831 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong Acids, sulfur, selenium, wood and other combustables	Site 3,4,5,7A,7C,8,9, 10A,10B,11,12,13,14, 16, & 19 Maximum Concen- tration at Site: 4 @ 7400 mg/kg	lungs, skin, nasal cavities	eye or skin irritation; pneumonia like illness; cough; shortness of breath; pulmonary edema

Figure 3-3
(continued)

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Selenium Se [7782-49-2]	Dark grey to dark red powder or crystals	MW: 78.96 BP: 685 °C (1265 °F) MP: 200 °C (392 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong acids, strong oxidizers, most common metals cadmium	Site 2, 3, 7C, 9, 10B, 13, 14, 16, & 19 Maximum Concen- tration at Site: 11 to 0.18 mg/L	Upper respiratory system, eyes, skin, liver, blood, kidneys, spleen	Irritation to skin, eyes, nose, and throat; dermatitis; nausea; vomiting; headaches; dizziness; gastrointestinal irritation
Silver Ag [7440-22-4]	white metal	MW: 107.8 BP: 2000 °C (3632 °F) MP: 960 °C (1761 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong acids, strong bases, oxygen	Site 4, 5, 7A, 7C, 8, 9, 10A, 10B, 12, & 15 Maximum Concen- tration at Site: 4 to 114 mg/kg	Nasal septum, skin, and eyes	Blue Gray eyes; nasal septum; throat; skin irritation; ulceration; GI distress
Vanadium V [7440-62-2] as Metal [1314-62-1] as V2O5	V2O5 is a yellow- orange powder	MW: 50.94 BP: 1750 °C (3182 °F) MP: 690 °C (1274 °F) VP: 0 mm Hg Sol: 0.8% as V2O5 FP: N/A LEL: N/A UEL: N/A IP: N/A	Lithium, Chlorine, trifluoride, acetylene, ammonia, hydrogen peroxide	Site 3, 4, 5, 6, 7A, 7B, 7C, 8, 9, 10A, 10B, 11, 12, 13, 14, 15, 16, & 19 Maximum Concen- tration at Site: 14 to 55.3 mg/kg	Eyes, Skin, respiratory sys.	Lung irritation; green tongue; coughing; wheezing; eczema
Zinc Zn [7440-66-6] as Metal [1314-13-2] as ZnO	Zn Oxidizes to a white colorless solid	MW: 65.39 BP: 908 °C (1666 °F) MP: 420 °C (787 °F) VP: 0 mm Hg Sol: Insol FP: N/A LEL: N/A UEL: N/A IP: N/A		Site 3, 4, 5, 7A, 7C, 8, 9, 10A, 10B, 12, 13, 14, 16, & 19 Maximum Concen- tration at Site: 17 to 5610 mg/kg	Resp sys as ZnO	Dry Throat; coughing; chills; fever; tight chest; blurred vision; headache; nausea; vomiting; malaise

**Figure 3-3
(continued)**

**Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ALAMEDA**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Fluorene	White Crystalline Powder	MW: 166 BP: 298 °C (568 °F) MP: 114-116 °C (237-241 °F) VP: Sol: LP: LEL: UEL: IP:	Strong oxidizers	Site 1, 2, 5, 6, 7C, 8, 9, 13, 16, & 19 Maximum Concen- tration at Site: 8 to 160,000 ug/kg		Irritation of eyes & skin, nausea, drowsiness

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**Figure 3-3
(continued)**

**Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ATAMEDA**

Contaminant (Synonym) (C.A.S. Number)	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Cyanide		MW BP MP VP Sol FP LEL UEL IP		Site 4 & 5 Maximum Concen- tration at Site 4 to 18 mg/kg		Asphyxia and death; weakness, headache; confusion; nausea, vomiting; increasing rate respiration, slow gasping respiration; irritation of eyes and skin

**Figure 3-3
(continued)**

**Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ALAMEDA**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Aldrin C12 H18 Cl6 [309-00-2]	White, tan, or dark brown crystalline material with a mild chemical odor	MW: 364.93 BP: Decomposes MP: 104 °C VP: 7.5E-5 mm Hg Sol: 0.001% FP: NA LEL: NA UEL: NA IP: NA	Hydrogen chloride gas, concentrated mineral acids, active metals, acid catalysis, acid oxidizing agents, phenol	Site 2 & 12 Maximum Concen- tration at Site: 12 to 28 ug/kg	CNS, liver kidneys, skin	Vomiting, diarrhea; renal damage; tremors; ataxia; convulsions; CNS depression; respiratory failure; death, coma
Alpha BHC	White crystals	MW: 291 BP: MP: 156 - 161 °C VP: Sol: FP: LEL: UEL: IP:	Strong oxidizing agents	Site 8 & 16 Maximum Concen- tration at Site: 16 to 37 ug/kg	Not thoroughly investigated	Eye, skin, and respiratory system irritation
Alpha Chlordane		MW: BP: MP: VP: Sol: FP: LEL: UEL: IP:		Site 1, 2, 7C, 8, & 14 Maximum Concen- tration at Site: 14 to 160 ug/kg		
Aroclor 1248 (Polychlorinated Biphenyl) (Chlorobiphenyl)	Liquid	MW: BP: MP: VP: Sol: FP: LEL: UEL: IP:	Strong oxidizing agents	Site 1, 2, & 16 Maximum Concen- tration at Site: 16 to 4,600 ug/kg	Kidney	Eye, skin, and respiratory system irritation

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**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Aroclor 1254 (Polychlorinated Biphenyl) [11097-69-1]	Light yellow viscous liquid	MW: 326 BP: 365-390 °C (689-734 °F) MP: 10 °C (50 °F) VP: 0.00006 mm Hg Sol: Insol FP: NA LEL: NA UEL: NA IP: NA	Strong oxidizing agents	Site 8 & 16 Maximum Concen- tration at Site: 16 to 21,000 ug/kg	Kidney, skin, eyes, liver, reproductive sys	Eye, skin, and respiratory system irritation, somnolence, diarrhea, reproductive effects
Aroclor 1260 (Polychlorinated Biphenyl)	Light Yellow, soft, sticky resin	MW: BP: 385-420 °C MP: VP: Sol: FP: LEL: UEL: IP:	Strong oxidizing agents	Site 1, 2, 8, 14, & 16 Maximum Concen- tration at Site: 16 to 7,300 ug/kg	Liver	Eye, skin, and respiratory system irritation; somnolence, diarrhea
Chlordane (Gamma Chlordane) C ₁₀ H ₆ Cl ₈ [57-74-9]	Viscous colorless to amber colored liquid with a pungent chlorine- like odor.	MW: 409.8 BP: Decomposes MP: 103-109 °C (217-228 °F) VP: 0.00001 mm Hg Sol: 0.0001 % FP: NA LEL: NA UEL: NA IP: NA	Strong oxidizers Alkaline reagents.	Site 1 & 2 Maximum Concen- tration at Site: 14 to 160 ug/kg	Kidneys, CNS, Liver, lungs, thorax, eyes.	Eye, mucous Membrane, Upper respiratory tract irritation Irritability, convulsions, & deep depression blurred vision, coughing, vomiting.
4-Chloro-2-Methyl- phenylacetic Acid (MCPA) C ₉ H ₉ ClO ₂ [94-74-6]	Tan Powder	MW: 200.61 BP: MP: VP: Sol: Insol FP: LEL: UEL: IP:	Strong oxidizers.	Site 8 Maximum Concen- tration at Site: 8 to 64 ug/kg	Liver	Somnolence, coma, gastritis, irritant

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
2-(4-Chloro-o-tolylxy) Propionic Acid (Meccoproq) (MCP) [10111-10-1]	tan powder	MW: 206 BP: 93-94 °C (199-201 °F) MP: 10-11 °C (50-52 °F) VP: 1.5E-7 mm Hg @ 20 °C Sol: Insol FP: 72-73 °C (162-171 °F) LEL: NA UEL: NA HP: NA	Strong oxidizers Strong bases	Site 8 Maximum Concentration at Site: 8 to 1030 ug/kg	Skin, eyes, respiratory tract	Spasm, inflammation and edema of larynx and bronchi, chemical pneumonitis, pulmonary edema, burning, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, vomiting
DDD [14110-14-1] [72-54-8]	N/A	MW: 120 BP: 110 °C (230 °F) MP: 10-11 °C (50-52 °F) VP: 1.5E-7 mm Hg @ 20 °C Sol: Insol FP: 72-73 °C (162-171 °F) LEL: NA UEL: NA HP: NA	Strong oxidizing agents	Site 1,2,7A,7C,8,13, 14, & 16 Maximum Concentration at Site: 1 to 85.3 ug/kg	Not thoroughly investigated	Harmful if swallowed, inhaled, or absorbed through skin.
DDD [14119-15-1]	N/A	MW: 154.5 BP: 110 °C (230 °F) MP: 88-90 °C (190-194 °F) VP: 1.5E-7 mm Hg @ 20 °C Sol: Insol FP: 72-73 °C (162-171 °F) LEL: NA UEL: NA HP: NA	Strong oxidizing agents, strong bases	Site 1,2,7A,7C,8,13, 14, & 16 Maximum Concentration at Site: 1 to 347 ug/kg	Liver	Harmful if swallowed, inhaled, or absorbed through skin; tremors; excitement; skin irritation; convulsions; anesthetic, somnolence; ataxia; headaches; analgesia; vomiting; nausea.
DDT [50-11-8] [133-49-9]	Colorless crystals or white powder with slightly aromatic odor.	MW: 354.5 BP: 110 °C (230 °F) MP: 99 °C (211 °F) VP: 1.5E-7 mm Hg @ 20 °C Sol: Insol FP: 72-73 °C (162-171 °F) LEL: NA UEL: NA HP: NA	Bases, oxidizing agents, alkalis	Site 1,2,7A,7C,8,13, 14, & 16 Maximum Concentration at Site: 8 to 521 ug/kg	Liver, CNS, eyes, kidneys, PNS, skin	Irritation to eyes, skin; tremors; dizziness; confusion; convulsions; vomiting.

Figure 3-3
(continued)

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
1,6-Dichloro-o-anisic acid (Dicamba) C8 H6 Cl2 O3 [1918-00-9]	Solid	MW: 221 BP: MP: 114-116 °C (237-241 °F) VP: 38E-6 mm Hg Sol: Slightly Soluble FP: LEL: UEL: IP:	Strong oxidizers	Site 8 Maximum Concentration at Site: 8 @ 50.6 ug/kg		Irritation of eyes, skin, mucous membranes, and upper respiratory system
Dieldrin C12 H8 Cl6 O [60-57-1]	Colorless to light tan crystals with a mild chemical odor.	MW: 380.9 BP: Decomposes MP: 176 °C (349 °F) VP: 8E-7 mm Hg Sol: 0.02% FP: NA LEL: NA UEL: NA IP: NA	Strong oxidizing agents, active metals such as sodium, strong acids, phenols	Site 1, 2, 8, & 14 Maximum Concentration at Site: 8 @ 52.6 ug/kg	CNS, Liver, blood, kidneys, skin	malaise; headache; vomiting; nausea; dizziness; coma; tremors; respiratory failure; somnolence; irritability; vomiting.
Endosulfan C9 H6 Cl6 O3 S [115-29-7]	Brown Crystals with sulfur dioxide odor.	MW: 406.95 BP: Decomposes MP: 106 °C (223 °F) VP: 0.00001 mm Hg Sol: 0.00001% FP: NA LEL: NA UEL: NA IP: NA	Alkalis, acids, water	Site 14 Maximum Concentration at Site: 14 @ 9.6 ug/kg	Skin, CNS, liver, kidneys, and reproductive sys.	Skin irritation, nausea, confusion, agitation, dry mouth, tremors, convulsions.
Endrin 1,2,3,4,10,14C (Endrin) C12 H8 Cl6 O [72-20-8]	Colorless to tan crystalline solid with a mild chemical odor.	MW: 380.91 BP: Decomposes MP: 200 °C (392 °F) VP: 2E-7 mm Hg Sol: Insol FP: NA LEL: NA UEL: NA IP: NA	Strong oxidizing agents, acids	Site 8 & 14 Maximum Concentration at Site: 8 @ 31 ug/kg	CNS, Liver	Epileptiform; confusion; convulsions; dizziness; stupor; headache; lethargy; abdominal discomfort; nausea; vomiting; insomnia; weakness; aggressiveness; anorexia

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Heptachlor-14C (Heptachlor) C ₁₀ H ₅ Cl ₇ [76-44-8]	White sand like material with camphor like odor	MW: 373.15 BP: 145°C (293°F) MP: 95°C (203°F) VP: 3E-4 mm Hg Sol: 0.0006% FP: NA LEL: NA UEL: NA IP: NA	Iron, rust	Site 2, 13, & 14 Maximum Concen- tration at Site: 2 to 12.4 ug/kg	Liver, CNS	Tremors; convulsions; excitement; spasticity; change in motor activity; aggression
1,2,3,4,5,6 Hexachloro- cyclohexane (Beta BHC)		MW: BP: 60°C (140°F) MP: 310°C (590°F) VP: <0.01 mm Hg Sol: FP: LEL: UEL: IP:	Strong oxidizers, bases, alkali metals	Site 13, 14, & 16 Maximum Concen- tration at Site: 13 to 15 ug/kg	Lungs, thorax, CNS	Irritation of eyes, upper respiratory tract, mucous membranes; nausea; dizziness, headache; CNS depression depression
1,2,3,4,5,6 Hexachloro cyclohexane (Gamma Isomer) (Gamma BHC, Lindane) C ₆ H ₆ Cl ₆ [58-89-9]	White Powder musty odor	MW: 290.9 BP: 32°C (61°F) MP: 111°C (235°F) VP: 9E-6 mm Hg @ 20°C Sol: 0.001% FP: NA LEL: NA UEL: NA IP: NA	Strong oxidizers, metals	Site 8, 14 & 16 Maximum Concen- tration at Site: 16 to 38 ug/kg	Blood, skin, CNS, eyes, liver, respiratory sys, kidneys.	Irritation of eyes, nose, throat; headache; nausea; chronic convulsions; respiration difficulty; cyanosis; aplastic anemia; skin irritation; muscle spasm.
Methoxychlor (C ₆ H ₁₁ ClO ₂) ₂ CH ₂ Cl ₃ [72-43-5]	Colorless to light yellow crystals with slightly fruity odor.	MW: 345.65 BP: Decomposes MP: 77°C (171°F) VP: very low Sol: 0.00001% FP: NA LEL: NA UEL: NA IP: NA	Strong oxidizers	Site 7A & 7C Maximum Concen- tration at Site: 7A to 37.6 ug/kg	CNS, kidneys skin, liver	excitement; convulsions; ataxia; trembling

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Toxaphene (Chlorinated Camphene) C ₁₀ H ₁₀ Cl ₈ [8001-35-2]	Liquid Yellow waxy solid with a mild, piney, chlorine and camphor like odor	MW: 413.8 BP: Decomposes MP: 65-90 °C (149-194 °F) VP: 0.4 mm Hg Sol: 0.0003% EP: NA TEL: NA UEL: NA HP: NA	Strong Oxidizers	Site 13 & 19 Maximum Concentration at Site: 13 (≈ 2500 ug/kg)	Eyes, kidneys, CNS, liver, skin	Irritation to eyes, mucous membrane, upper respiratory tract, skin irritation, somnolence, coma, excitement, convulsions

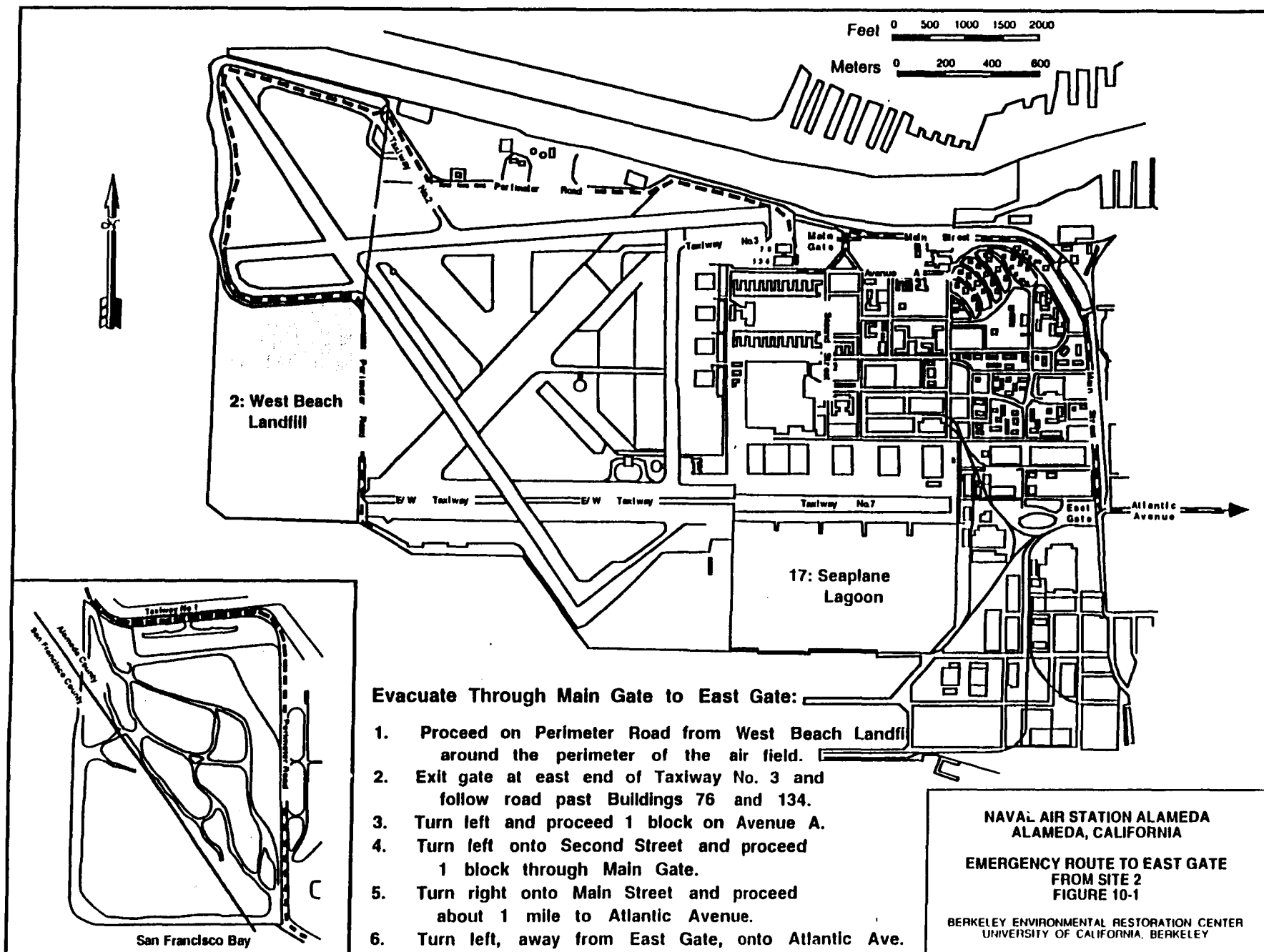
**Figure 3-3
(continued)**

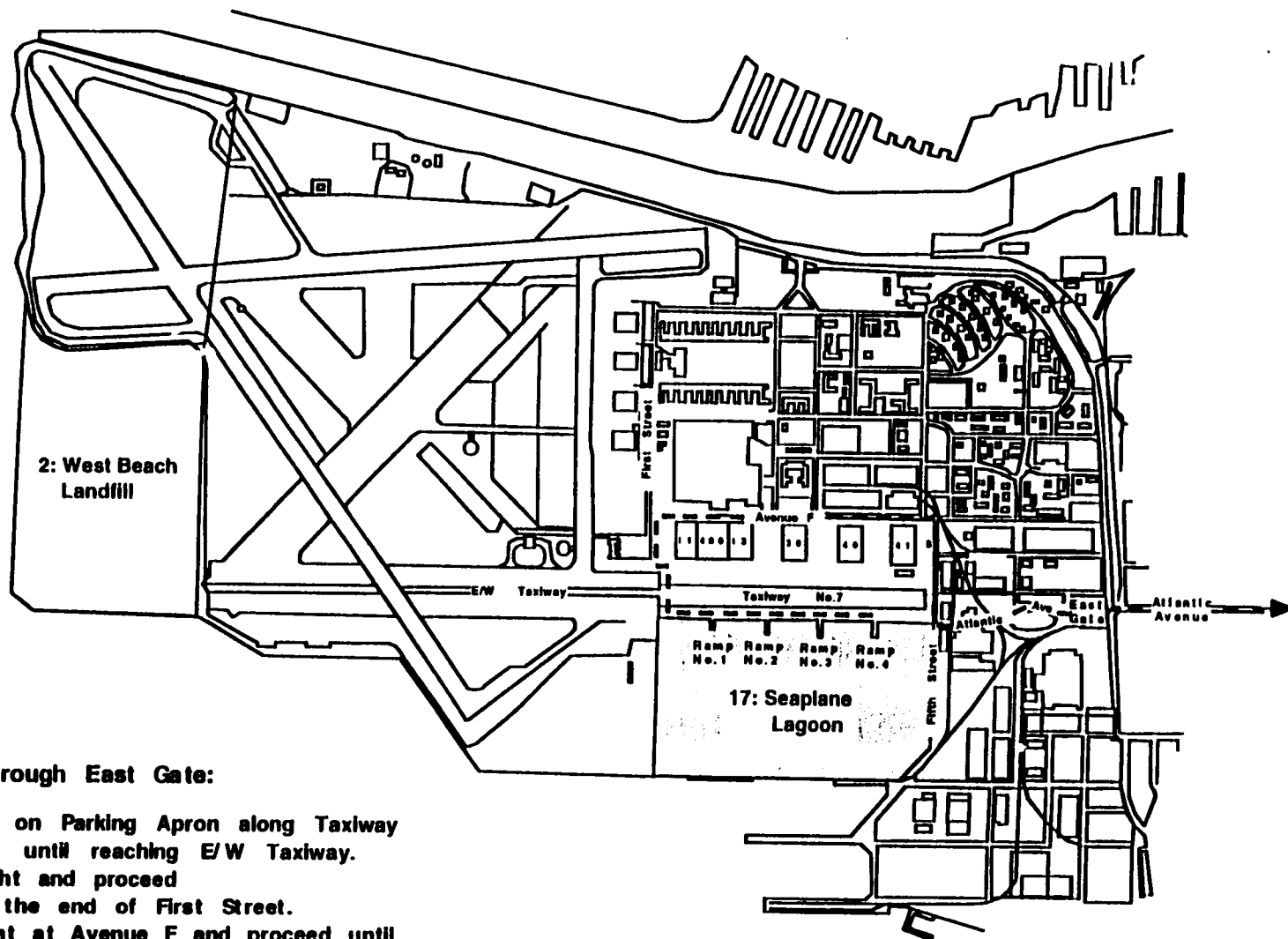
**Table 1
HAZARDOUS AND TOXIC MATERIALS
NAS ALAMEDA**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Bromacil <chem>C9H11BrN2O2</chem> [114-40-9]	White crystalline odorless solid	MW: 261.11 BP: Sublimes MP: 157 °C (315 °F) VP: 8E-4 mm Hg @ 100 °C Sol: 0.002% FP: NA LEL: NA UEL: NA IP: NA	Strong Acids, oxidizers, heat, sparks, open flames	Site 8 Maximum Concen- tration at Site: 8 @ 10.2 ug/L	eyes, skin, thyroid, respiratory sys	Irritation to eyes, skin, and upper respiratory system
1-(4-Chlorophenyl)-1,1-dimethylurea (Monuron) <chem>C9H11ClN2O</chem> [150-68-5]	N/A	MW: 198.65 BP: MP: 170-171 °C (338-340 °F) VP: 5E-7 mm Hg @ 25 °C Sol: Slight FP: LEL: UEL: IP:	Strong oxidizers	Site 8 Maximum Concen- tration at Site: 8 @ 8.8 ug/kg	Liver, Kidneys	Anemia; skin irritation; cyanosis
2,4-D (Dichlorophenoxyacetic Acid) <chem>C12Cl2H10O2Cl2COOH</chem> [94-75-7]	White to Yellow Crystalline, odorless powder	MW: 221.0 BP: Decomposes MP: 138 °C (280 °F) VP: 0.4 mm Hg @ 160 °C Sol: 0.05% FP: N/A LEL: N/A UEL: N/A IP: N/A	Strong oxidizers	Site 8 Maximum Concen- tration at Site: 8 @ 280 ug/kg	Skin, CNS, liver, kidneys	Weakness; stupor; muscle twitches; hyporeflexia; convulsions; dermatitis
1-(1,4-Dichlorophenyl)- 1,1-dimethylurea (Duron) <chem>C6H3Cl2N1C1N1C1H3O2</chem> [110-54-1]	White odorless crystalline solid	MW: 223.1 BP: 180 °C (356 °F) MP: 158 °C (316 °F) VP: 2E-9 mm Hg Sol: 0.004% FP: NA LEL: NA UEL: NA IP: NA	Strong oxidizers, strong acids, strong bases	Site 8 Maximum Concen- tration at Site: 8 @ 1.3 ug/L	Liver, kidneys, eyes, skin, blood, respiratory sys	Irritation of eyes, skin, mucous membranes, upper respiratory tract; CNS depression; gastrointestinal disturbances

**Figure 3-3
(continued)**

Contaminant (Synonym) [C.A.S. Number]	Physical Description	Chemical & Physical Properties	Incompatibilities	Sources & Anticipated Concentration	Target Organs	Symptoms of Exposure
Glyphosate (Phosphonomethyl HCl) <chem>C(C1=CC=CC=C1)N(C(C(=O)O)OP(=O)(O)O)C1=CC=CC=C1</chem> [1071-83-6]	White Solid	MW: 169.07 BP MP: 230 °C VP Sol: 12 g/l FP TLV OEL HP	Stable	Site 16 Maximum Concentration at Site: 16 to 1 ug/kg	Heart, Lungs, Thorax	Convulsions; change in heart rate; respiratory problems; diarrhea, body temperature increases





Evacuate Through East Gate:

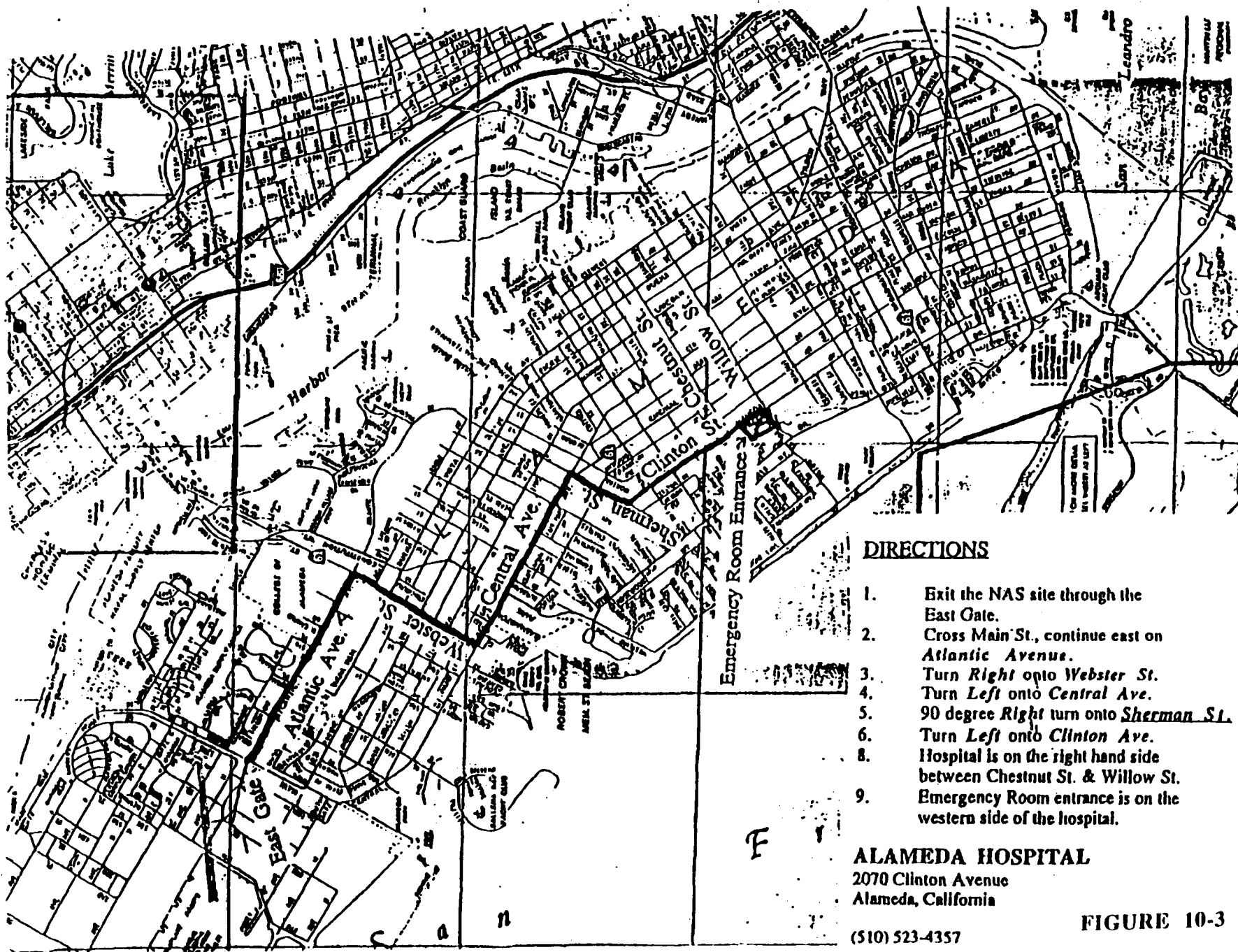
1. Proceed on Parking Apron along Taxiway No. 7 until reaching E/W Taxiway.
2. Turn right and proceed along the end of First Street.
3. Turn right at Avenue F and proceed until reaching Fifth Street.
4. Turn right and proceed along Fifth Street until reaching Atlantic Avenue.
5. Turn left on Atlantic Avenue and proceed until reaching East Gate.

**NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA**

**EMERGENCY ROUTE TO EAST GATE
FROM SITE 17
FIGURE 10-2**

**BERKELEY ENVIRONMENTAL RESTORATION CENTER
UNIVERSITY OF CALIFORNIA, BERKELEY**

Emergency Hospital Route



DIRECTIONS

1. Exit the NAS site through the East Gate.
2. Cross Main St., continue east on Atlantic Avenue.
3. Turn Right onto Webster St.
4. Turn Left onto Central Ave.
5. 90 degree Right turn onto Sherman St.
6. Turn Left onto Clinton Ave.
8. Hospital is on the right hand side between Chestnut St. & Willow St.
9. Emergency Room entrance is on the western side of the hospital.

ALAMEDA HOSPITAL

2070 Clinton Avenue
Alameda, California

(510) 523-4357

FIGURE 10-3

ATTACHMENT 3-2 Job Hazard Analysis Form

Sediments Intrinsic Remediation Treatability Study
Sample Collection

ACTIVITY STEPS	ACTUAL OR POTENTIAL HAZARDS	RECOMMENDED HAZARD CONTROL
1. Mobilization to site	Vehicle traffic	See SSP 12.3- Be aware of vehicles Wear traffic vests if working in traffic
	Materials handling Slip, trip and fall	See SSP 12.1- Use safe lifting procedures See SSP 12.17- Inspect work areas Maintain good housekeeping Use appropriate footwear
2. Hand Augering	Slip, trip and fall	See SSP 12.17- Inspect work areas Maintain good housekeeping Use appropriate footwear
	Materials handling Contact with contaminated materials	See SSP 12.1- Use safe lifting procedures See HSP 7- Use specified PPE Establish work zones Follow decon procedures
3. Groundwater sampling	Slip, trip and fall	See SSP 12.17- Inspect work areas Maintain good housekeeping Use appropriate footwear Maintain good housekeeping
	Materials handling Contact with contaminated materials	See SSP 12.1- Use safe lifting procedures See HSP 7- Use specified PPE Establish work zones Follow decon procedures

Attachment 3-2
Job Hazard Analysis Form (Cont'd)

Sediments Intrinsic Remediation Treatability Study
Sample Collection

ACTIVITY STEPS	ACTUAL OR POTENTIAL HAZARDS	RECOMMENDED HAZARD CONTROL
4. Soil gas sampling	Slip, trip and fall Materials handling Contact with contaminated material	See SSP 12.17- Inspect work areas Maintain good housekeeping Use appropriate footwear See SSP 12.1- Use safe lifting procedures See HSP 7- Use specified PPE Establish work zones Follow decon procedures
5. Sediment sampling	Slip, trip and fall Materials handling Contact with contaminated material Working on or near water	See SSP 12.17- Inspect work areas Maintain good housekeeping Use appropriate footwear See SSP 12.1- Use safe lifting procedures See HSP 7- Use specified PPE Establish work zones Follow decon procedures See HSP 11.3- Wear PFDs
6. Acoustic Imaging	Slip, trip and fall Materials handling Contact with contaminated material Working on or near water Electrical hazards associated with equipment	See SSP 12.17- Inspect work areas Maintain good housekeeping Use appropriate footwear See SSP 12.1- Use safe lifting procedures See HSP 7- Use specified PPE Establish work zones Follow decon procedures See HSP 11.3- Wear PFDs See HSP 11.4

ATTACHMENT 4-3

TAILGATE HEALTH AND SAFETY FORM		
Site Supervisor:		SHSO:
Meeting Held By:		Date:
SUMMARY OF WORK LOCATION AND ACTIVITIES		
<i>Site Hazards Evaluation</i>	<i>Circle</i>	<i>Circle</i>
Toxic Vapors	Yes	No
Explosivity	Yes	No
Equipment	Yes	No
Steam	Yes	No
Physical Hazards (<i>Specify</i>)	Yes	No
Personal Protective Equipment (<i>Specify</i>)	Yes	No
Decontamination Procedures (<i>Specify</i>)	Yes	No
EMERGENCY INFORMATION		
First Aid Location	Yes	No
Hospital Route Location	Yes	No
Emergency phone number and phone location	Yes	No
SIGNATURES		
Team Member	Signature	Date

ATTACHMENT 7-4
FIELD EQUIPMENT LIST

This is a list of required equipment for use on site. This list may be modified according to site conditions and activities.

PERSONAL PROTECTIVE EQUIPMENT (General site work outside EZs):

- Hard hat
- Safety glasses with side shields
- Long sleeved shirts
- Cotton or leather gloves
- Foot wear with steel toe and shank

PERSONAL PROTECTIVE EQUIPMENT:

- Hard hat
- Safety glasses with side shields
- Coast Guard approved personal flotation devices when working on or near water
- Polyethylene coated Tyvek suits
- Nitrile gloves with surgical inner gloves
- PVC or neoprene boots with steel toe and shank

DECONTAMINATION EQUIPMENT:

- plastic liners
- six mil polyethylene drop cloths
- containers (20-30 gallons)
- decontamination solution or detergent water
- pressurized spray unit (Hudson sprayer)
- water
- 5 to 6 long-handle, soft-bristle scrub brushes
- bench, or other seating
- wash basins or buckets
- hand soap, wash basins and towels

MONITORING EQUIPMENT:

- CGI/Oxygen meter
- Hydrogen sulfide monitor
- Calibration gases and equipment

MISCELLANEOUS EQUIPMENT:

- First aid kit
- Eyewash and/or shower
- Absorbent material
- Fire extinguishers (10 ABC rated)
- Hand-held alarm horns

ATTACHMENT 10-5
ACCIDENT/INCIDENT REPORT FORM

***BERC* ACCIDENT/INCIDENT REPORT FORM**

(Sheet 1 of 2)

**SITE SUPERINTENDENT REPORT OF ACCIDENT/INJURY
(USE FOR ON-SITE ACCIDENTS OR EXPOSURES ONLY)**

To: Michael Connor., CIH,
ATG Certified Industrial Hygienist

From: ATG's Site Health and Safety Officer

Telephone Number ____ / ____ - ____

Project No.: _____

Site Name: _____ Exact Location of Accident/Injury _____

Name of Injured/Ill Employee(s): _____

Date and Time of Accident/Injury: _____

Description of Accident/Injury: _____

Nature of Illness or Injury and Part of Body Involved: _____

Probable Disability (check one):

- ☐ Fatal
- ☐ Lost work days (No. of days: ____)
- ☐ Restricted activity (No. of days: ____)
- ☐ First aid only

ATTACHMENT 10-5

ACCIDENT/INCIDENT REPORT FORM (CONT'D)

***BERC* ACCIDENT/INCIDENT REPORT FORM**

(Sheet 2 of 2)

Corrective Action(s) Taken by Reporting Unit: _____

Corrective Action That Remains to be Taken (By whom and by when):

ATG Project Manager: _____

ATG Site Superintendent: _____

Signature: _____

Date: _____

cc: Mark Freiberg, UCB Program CIH

APPENDIX A

WATER SAFETY

The proper operation of the boat is paramount to site worker safety on the water. Of critical importance to boat operations is the selection of the type and configuration of vessel staffed by a licensed and experienced crew. Nearly as important to worker safety is familiarity with sampling activities and their effect on vessel handling and stability. Finally, site workers must be trained and experienced in operating sampling equipment from a boat. For example, proper orientation of the boat with respect to the prevailing sea conditions will allow workers to operate from a stable platform and be protected from destabilizing winds and seas that can affect footing and equipment movement.

The boat operator must be skilled in boat operations and exhibit good seamanship to ensure that vessel movement does not create unsafe conditions. The boat operator and vessel must meet all Federal and State boating and licensing regulations. All safety equipment must meet US Coast Guard standards for type, quantity, and seaworthiness. Site workers must also be briefed on boating hazards and be familiar with the safety equipment and emergency procedures onboard the boat. If the site workers double as the boat's crew they should be proficient in donning and doffing life vests while wearing the prescribed PPE and demonstrate an understanding of man-overboard procedures, in addition to requirements mandated by the vessel operator.

Dry-runs in which sampling equipment is operated and moved shall be conducted to expose and resolve any fundamental problems. These may be done alongside the dock prior to getting underway, so that the placement and movement of equipment and personnel can be scrutinized under ideal conditions. Mock emergencies, like man overboard drills, will be carried out to train and test the crew's readiness to respond to these emergencies.

Special Notes: Recommended and required items not otherwise covered:

- Boat operations in Seaplane Lagoon and approaches will be discussed with the base Operations Officer or other representatives to identify known hazards. Permission to operate a vessel within the restricted waters surrounding NAS Alameda must be obtained from the base Operation Officer prior to entry.
- It is anticipated that these activities will not hamper vessel traffic, therefore, no Notice To Mariners appears warranted.
See the "Notes" on marine chart number 18650 for special information.

Hazards: Since sampling will take place from a boat operating on bay waters, several hazards associated with boating activities are present:

Drowning: The greatest care shall be taken to ensure that personnel remain in the boat through the proper operation of the vessel and the diligent efforts of site workers to remain within and upon the boat. The following precautions shall also be undertaken:

1. Use of the buddy system during boat operations;
2. The wearing of life vests;
3. The availability of a life ring with line or other apparatus suitable for recovering a man overboard, and
4. Having at least one person on the vessel trained in CPR.

Slip, trip and fall hazards: Boats are in constant motion, either from wave or wind action or from activities aboard the boat, quarters are cramped and the deck is adorned, with trip hazard like cleats and hatch covers. Sampling activities focus attention upon cables, winches and pulleys, and away from these hazards making it likely that injuries from falling or tripping will occur unless participants remain diligent to these conditions and take adequate precautions. Dry-runs will be performed to help acquaint workers with these hazards and how to avoid them.

Sea Sickness: Most people, in some form or another, feel the effects of vessel motion, calling it sea sickness. Reactions can range from tiredness to headaches to nausea, with the latter the most common effect for persons new to boating. Seasoned boaters often report that they tire more easily, but otherwise show no other outward symptoms. Sea sickness can lead to severe nausea, disorientation and extreme fatigue - all of which can rapidly contribute to unsafe conditions for site workers. Sea sickness symptoms often take many hours to pass. Prior to any assignment to boating activities, all workers shall discuss with the Site Health and Safety Officer their experience aboard boats, their sensitivity to seasickness, and the precautions they take. The use of any medication or device used by the site worker to mitigate the effects of sea sickness shall be disclosed to the SHSO prior to boarding the boat because these precautions often have side-effects that can affect ones ability to perform work safely.

Fatigue: Persons unaccustomed to operating aboard boats will notice that it takes a lot of effort to remain stable, whether standing or seated. The motion of the boat causes one to use more muscles in order to remain balanced, resulting in fatigue. Prior to conducting boating operations, the SHSO will conduct training on identifying fatigue, in understanding its effects and adjusting work assignments and duration accordingly.

Hypothermia: Hypothermia is the lowering of the body's internal temperature, usually from exposure to cold air, wind, or water. Early symptoms are bluish skin and lips, incoherent speech and shivering, followed by reduction in muscle movement and control, mental disorientation, and eventually unconsciousness. The greatest danger of hypothermia at this site is from immersion in the bay by falling overboard, but hypothermia can set-in under lesser conditions if exposure is over a long period of time. If work requires prolonged exposure to cold conditions, the work schedule will include warm-up breaks and making frequent checks for signs of hypothermia. The SHSO will familiarize site personnel with first aid techniques for hypothermia.

Tides and Currents: The boat operator shall have thorough knowledge of the tides and currents for the areas traversed. This can be accomplished by computing the tides and currents using appropriate resources or through requesting this information from marina operators or the U.S. Coast Guard. The period of

minimal tidal action is known as slack tide. It is recommended that sampling activities coincide with periods of slack tide to minimize the effects of tides and currents. Proper understanding of the effects of these actions upon ones vessel and acting accordingly should reduce this hazard to negligible levels.

Weather: The vessel operator shall have knowledge of the weather report for the areas traversed covering the time the vessel is to be underway. This can be accomplished by listening to the marine weather broadcast from the National Weather Service (Channel 2 VHF FM) or other competent source. Vessels of less than 5 net tons shall not be operated during periods when a small craft warning (or higher warning level) is in effect.

Vessel Traffic: The boat operator shall maintain an adequate distance away from other vessel traffic, to avoid collision. The boat operator is encouraged to monitor U.S. Coast Guard Vessel Traffic Service broadcasts on Channel 12 VHF FM as needed to remain apprised of vessel traffic in the area.

Lights, Day-shapes and Sound Signals: The boat operator shall energize the vessel's lights, necessary and prescribed safety equipment for boat operations; however, normal boating conditions can quickly make safety equipment unserviceable, making an inspection of the safety equipment of paramount importance prior to getting underway. The SHSO shall conduct an inspection of the vessel to ensure it is in compliance with applicable laws and regulations and is encouraged to make use of the Coast Guard Auxiliary or the U.S. Coast Guard to assist in making this determination. In addition to the required equipment:

The vessel shall:

- Carry current marine charts for the waters upon which the vessel will be operated. For operations in and around NAS Alameda the applicable chart is Chart Number 18650 (Candlestick Point to Angel Island).
- Be fitted with an U.S.C.G. approved 30 inch life ring with at least 90 feet of 600 pound capacity line.
- Be fitted with an operable marine band VHF-FM radio in CH 2, 16, 21 and an alternate.
- Be operated by a qualified operator.
- Be maintained in good working order and shall conform to U.S. C.G. requirements for its use.

The vessel operator shall:

- Review the man overboard procedures with all individuals aboard before work begins.
- Ensure that the towing bridles and personal flotation devices are inspected weekly. Damaged equipment shall be taken out of service.
- Provide safe access and egress to the vessel.

All individuals shall:

- Wear an U.S.C.G. approved and serviceable Type III or higher personal flotation device.
- Stay clear of towing bridles or other lines under stress.

Vessel Licensing: A vessel hired by the University must comply with 46 CFR (Code of Federal Regulations), the boat operator must be licensed for the intended number of passengers and the boat must have the proper safety equipment as well as current registration/documentation. In general, six or less passengers can be accommodated on the most limited license, more passengers requires a broader license. If the vessel is wholly owned by the Federal government there are no licensing requirements, but the vessel operators shall have thorough knowledge of the vessel and its operation, as determined by a review of documentation or through live demonstration, prior to its use on any BERC project.

Vessel Certification and Registration: Commercial vessels shall conform to the certification requirements set forth in 46 CFR as well as additional State and Federal laws and regulations as applicable. State registered vessels shall conform to State registration requirements as appropriate for its use and class. Proper certification and registration should limit any hazards associated with vessel worthiness and equipage.

SHSO Duties: See above for details. Summarized as follows:

- Become thoroughly familiar with the work activities to be performed on the water.
- Inspect safety equipment (may be completed by competent authority) and verify that the appropriate documentation is onboard (chart, registration, COLREGS). Ensure that the vessel's marine radio is operating properly and has the capability to operate on Channels 16, 13, another channel of your choice, and can monitor Channel 12 VHF FM and that the SHSO's radio operates on the channel of choice, as a minimum. Conduct a radio check between the two radios.
- Ensure that the vessel operator has the requisite licensing and is operating the vessel with the appropriate certification/registration as required by 46 CFR and other applicable laws and regulations.
- Certify that the sampling team has completed at least the 24 hour OSHA training for Occasional Site Workers. Brief observers on health and safety hazards associated with sampling activities.
- Ensure that the NAS Alameda Operations Officer has been contacted and permission has been granted to conduct operations within the restricted water surrounding the base.
- Ensure that the vessel operator has knowledge of the tides and currents and the day's weather report.
- Determine if the day's activities will hinder vessel traffic and issue a Notice To Mariners if warranted.

APPENDIX B

ACOUSTIC IMAGING SAFETY PLAN



BERKELEY ENVIRONMENTAL RESTORATION CENTER
3114 ETCHEVERRY HALL # 1750

COLLEGE OF ENGINEERING
BERKELEY, CALIFORNIA 94720-1750

June 28, 1996

Mr. Ken Spielman
EFA West, Code 18314
900 Commodore Drive
San Bruno, California 94066-5006

Re: BERC'S Acoustic Imaging Project NASA Safety Plan

Mr. Spielman,

In response to Gilbert Nickelson's review of BERC's above mentioned Safety Plan, enclosed are two copies of the revised Safety Plan for the Acoustic Imaging survey for the Seaplane Lagoon at NAS Alameda. Both copies contain the same revisions to the previously submitted safety plan. In the first copy, revisions are done in italics for your convenience in review. The second copy is identical but without italics. If the revisions are acceptable, the latter copy should be considered the draft Safety Plan submitted for the Navy's approval and will be the governing document for the proposed study.

Sincerely,

A handwritten signature in cursive script, appearing to read "William R. Williams".

Patrick Williams
Seismographic Station,
475 McCone Hall
mail stop 4760
University of California
Berkeley, Ca 94720
Phone 510-486-7156

encl.: ANAS Acoustic Imaging Project, two copies

Acoustic Imaging Safety Plan 2.1

**Acoustic Imaging Project
Alameda Naval Air Station
Safety Officer:**

Patrick Williams
Seismographic Station, 475 McCone Hall
mail stop 4760
University of California
Berkeley CA 94720
phone 510-486-7156

References:

1. Provisional Operators Manual for IKB-Seistec™ Model B3 (seismic source).
2. Instruction Manual for EG&G Environmental Equipment™ Model 234 (seismic energy source).
3. 29CFR 1926.106
4. US Army Corps of Engineers Safety and Health Requirements Manual EM 385-1-1: Section 05.I (personal floatation devices) ; Section 05.J (rescue skiffs); Section 19 (small craft).
5. U.S. Coast Guard Regulations For Small Craft
6. ANAS Sediments Work Plan; Health and Safety Section; Subsection 11.3 Water Safety;
7. Program Health and Safety Plan; Volume 1, Revision 3, October 1995; Control of Hazardous Energy, Section 12.6; Portable Electric Equipment, Section 12.19

Field supervisors (Williams and Clymer) developed a similar Safety Package prior to conducting 6-weeks of field work with identical equipment in fall of 1994. All safety protocols have been reviewed and updated for this Safety Package.

Introduction

This project consists of a marine acoustic reflection survey providing detailed information on bathymetry and depth to key strata in the Alameda Naval Air Station area (ANAS). Very High Resolution (VHR) sub-bottom profiling will be our primary tool for these investigations.

The VHR system consists of an electro-mechanical sound source utilizing high voltages and high current discharges. Additionally, high voltage power supplies and triggered capacitor banks are used and must be operated with caution. The VHR system also utilizes conventional micro-computer platforms for its navigation and data recording systems.

1. Hazards

1.1 Physical Hazards:

The project is being conducted on a relatively exposed vessel on the waters of San Francisco Bay and ANAS. Wind and wave conditions can vary considerably, but Bay conditions always involve cold water temperatures. Electrical cables for the acoustic imaging data acquisition equipment will be present. These cables combined with the confined deck space and wet conditions present trip and entanglement hazards.

1.2 Fire Hazards:

There are no flammable materials being used with the exception of vessel and generator fuels. Minor electrical fire hazards exist.

1.3 Electrical Hazards:

The VHR data acquisition system consists a several devices which utilize high voltages and high current discharges. The high voltage power source used by VHR consists of a triggered capacitor bank. A generator producing 110v AC power will also be on board. The safety systems and procedures specified in the accompanying manual are designed prevent shock hazards during the operation of electrical systems.

1.4 Auditory Hazards

The electro-mechanical sound source is of a type that has been in use for approximately three decades. The VHR sound emission amplitude and recurrence are well below hazard levels, and there is no warning requirement

1.5 Chemical Hazards:

There are no chemical hazards.

1.6 Radiation Hazards:

There are no radiation hazards.

1.7 High Pressure Hazards:

There are no high pressure hazards.

2. Hazard Mitigation:

2.1 Physical Hazards:

Standard water safety measures must be taken when operating on the deck of the vessel. Life vests will be worn by all personnel at all times. The survey equipment will be positioned to minimize exposed power and signal cables and to provide a safe layout of these cables. Low beams and cables will be marked or flagged for improved visibility. No operation will be allowed in wave heights exceeding 1.5 feet. An industrial quality first aid kit will be kept aboard at all times.

2.2 Fire Hazards:

No refueling will be undertaken while underway. All fueling will be accomplished at mooring or at a fueling dock. One 30 cu. in. or larger fire extinguishers, and two 10 cu. in. or larger fire extinguishers will be readily accessible at all times and will be deployed in forward, stern and mid positions aboard the vessel.

2.3 Electrical Hazards:

A safety manual concerning electrical hazard mitigation has been prepared and shall be read by all members of the working crew (see attached). University of California Lawrence Berkeley Laboratory EHS has completed an electrical safety inspection of our acoustic imaging equipment: The LBL EHS electrical inspectors name is Kieth Gershon 510/486-7067. Rich Clymer and Pat Williams have completed Gershon's Electrical Safety Training class.

2.4 Auditory hazards

No environmental or personnel hazard mitigation is required

3. Vessel Safety and Operational Procedures

Introduction

This manual is designed to illustrate and mitigate potential hazards involved in operation the data acquisition equipment being used for the ANAS Acoustic Imaging Project. Descriptions of required procedures for the safe deploying and retrieving of the equipment are included. Safety guidelines for field work aboard the project vessel are also detailed.

3.1 Standard Operational Procedures

A 28' Motor Vessel "Vessel Assist San Francisco", and a USCC Licensed operator (John C. Butcher; USCG Master's License) will be employed for the ANAS Acoustic Imaging study. The "Vessel Assist San Francisco" has a 10' foot beam and draws 2 feet. It is fully outfitted with USCG-regulated safety equipment. The operator of the "Vessel Assist San Francisco", will assure that marine and safety equipment is maintained in good working order and shall conform to U.S.C.G. requirements for its use.

The vessel operator shall:

- Review the man overboard procedures with all individuals aboard before work begins.

- Ensure that the towing bridles and personal flotation devices are inspected prior to startup. Damaged equipment shall be taken out of service.

- Provide safe access and egress to the vessel.

The vessel shall:

- Carry current marine charts for the waters upon which the vessel will be operated. For operations in and around NAS Alameda the applicable chart is Chart Number 18650 (Candlestick Point to Angel Island).

- Be fitted with an U.S.C.G. approved 30 inch life ring with at least 90 feet of 600 pound capacity line.

- Be fitted with an operable marine band VHF-FM radio on CH 2, 16, 21 and 74.

- Comply with all US Coast Guard and Small Craft regulations.

All project participants must review the following Standards of Operation:

a. All individuals shall wear an U.S.C.G. approved and serviceable Type III or higher personal flotation devices all times when aboard the vessel.

b. When docking, care must be taken when boarding and leaving the vessel. No jump should be undertaken when there is doubt as to whether the vessel is in motion. A severe crushing hazard is present during these times and the vessel cannot be maneuvered with control during these times.

c. Take care to stay clear of any possible collision or pinching hazard between vessels, dock and equipment. Safety on this vessel, as anywhere, requires staying alert.

d. Care must be taken when walking on the deck while the vessel is underway. Ropes should not obstruct paths, and if found this way, they should be cleared. Good housekeeping is required.

e. Regarding ropes: Stay clear of towing bridles or other lines under stress

1. Ropes under a load must be anticipated and handled with caution. Crushing and/or pinching is a hazard. Gloves must be worn and dangerous hand/finger positions must be avoided.

2. Entanglement is a substantial hazard. Never entangle feet or hands (includes wrapping of ropes around hands). Be aware of others when operating in close proximity.

f. Familiarity with life ring location is vital. Procedure for man overboard must be known by all crew members.

a. Man overboard procedure is as follows: (1) Yell "Man overboard" immediately. (2) Throw life ring to overboard personnel. (3) Bring the vessel around. (5) Keep overboard personnel in sight at all times. (6) Retrieve personnel over stern

3.2 Equipment Deploying/Retrieving Procedure:

Safety Issues:

- a. When a load is present on any line or cable, handle with caution. See section on rope and cable safety above.
- c. Tow ropes must remain tied off to deck cleats.

Operational Issues:

- a. Manpower requirements (3 total) - one handles the tow rope (securing and controlling slack); one handles the power cables (keeping free and avoiding excessive tension or slack); one handles the boat-hook (controlling swing and keeping Seistec sled pushed away from the stern of the vessel).
- b. Tow rope must always be secured before deploying/retrieving.
- c. Do not allow any hanging equipment to swing free. Keep equipment securely tied off when not in use. During loading operations, all personnel must remain out of harms way.
- d. Tow rope length adjusted and power cables are secured (maintaining adequate slack being maintained).
- e. Retrieval procedure is the reverse of deploying.

4. Electrical Safety and Operating Procedures Manual

4.1 Safety Protocols for High Voltage:

The safety protocol for general Lockout/Tagout requirements and portable electric equipment will be implemented as stated in the General Health and Safety Plan, Revision 3, sections 12.6 and 12.19 October 1995. Electrical systems, equipment and procedures will be reviewed by Keith Gershon , EH&S Electrical Inspector, Lawrence Berkeley National Laboratory. Redundant safety systems have been incorporated in the design of the systems. For example, three separate shut-offs are available for the high voltage system:

(Switching circuit breaker on the face of the EGG power supply to open (DOWN) Position; 2. Unplugging of high voltage power cable from EGG power supply; 3. Shutting generator off.)

Both sea-water grounding and GFI protection is employed on all electrical components. No electrical system will be altered while power is on. No live wires will be handled during the Acoustic Imaging field work. Thus the requirements specified for live wire safety under 29-CFR 1926.106 are not applicable. High voltage components will be separated from boat decks by

rubber mats. A set of lineman's gloves will be kept readily available to mitigate hazard to anyone handling a potentially dangerous electrical component during an emergency situation.

The Acoustic Source is powered by a 115V 3 kW generator and EG&G Model 234 power supply (capacitor bank). The Model 234 serves to convert 115VAC to 3.5-3.8KVDC, and supply this on demand to the acoustic source unit in 100 to 300 Joule pulses. The Model 234 is controlled by a timing unit to discharge at 2 to 4 pulses per second at 3.5kV. The electrical pulse is carried from the power supply to the acoustic source by a an AWG #10/4 electrical cable of 600V continuous rating. Note: (from Manual for IKB-Seistec™ Model B3 (seismic source)): "The throughput energy is relatively small and well within the capacity of the cable, high voltages are involved for only very short periods - less than 1 millisecond."

- a. To prevent shock from undetected electrical leakage (insulation failure), the high voltage power cable will not be handled while the high voltage system is powered.
- b. The high voltage cable shall be marked with numerous wraps of orange fluorescent safety tape
- c. The high voltage system is only to be powered while in test mode or while under way.
- d. The primary work area will be secured prior to high voltage charging. All hands will be alerted to the status of the high voltage system by the project leader (Williams), with a call of "SOUNDING SYSTEM CHARGED". Upon shut down of the system Williams will call out: "SOUNDING SYSTEM SHUT OFF".
- d. High voltage power supply unit must be kept dry, and so is to be situated for protection from spray and rain.
- e. All equipment access panels will remain closed during active field operation. No alteration or bypass of locked-out or tagged-out panels will be undertaken to any powered system. All power will be shut down and discharged prior to opening panels for any reason.
- f. No system will be charged with any access-panels removed.
- g. A seawater grounding conductor will be deployed and grounding cables will be connected to the chassis of all electrical equipment. These Grounding cables must remain securely in place:

1. generator grounded to seawater
 2. EGG power supply grounded to sea water
- h. Ground Fault Interrupters will be placed at the output of all electrical generators.
- i. Primary breaker switches must be easily accessible to facilitate rapid shut down in the event of emergency.

Note: Three high voltage shut down options are available:

1. Switch circuit breaker on the face of the EGG power supply to open (DOWN) Position .
2. Unplug high voltage power cable from EGG power supply.
3. Shut off generator.

4.2 Operating Procedures and Safety Protocols for 115VAC powered systems:

- a. The electrical cords and cables must be kept neat and organized. Stepping on cords must be avoided to prevent abrasion. Condition of electrical cables must be checked daily before operation begins.
- b. Read accompanying materials (sections 2.3 and 3.2.3. for handling of Seistec and EGG power supply..
- c. Car batteries used for various systems can cause shocks; do not touch both terminals at once.
- d. Know shut off options for utility AC power:
 1. Generator shut off.
 2. Plug patch panels.
 3. Equipment shut-off.

APPENDIX D
RESPONSES TO COMMENTS
ON DRAFT WORK PLAN

Response to Comments on Intrinsic Sediment Processes Study Draft Work Plan

Comments on the Draft Treatability Study Work Plan, Intrinsic Sediment Processes Study, were received by the Berkeley Environmental Restoration Center (BERC) on 12 December 1996. The following responses were prepared by BERC as a follow-up to the comments. Responses are required by the U.S. Navy as part of the technical review of the work plan, with some responses resulting in changes in the text of the work plan.

Comments were received from several groups, including the US EPA, PRC Environmental Management, Inc., the Navy's Environmental Sciences Division of San Diego, and several persons and a subcontractor associated with the Naval Facilities Engineering Services Center (NFESC), Port Hueneme, CA. Some general responses to recurring comments are addressed immediately below, and the text for these responses has been incorporated into the Work Plan. Responses to specific sets of comments follow the general responses:

General Response A: Intended uses of information from proposed studies.

The studies to be conducted by BERC are primarily intended to provide data to be used in the context of a feasibility study that will be prepared by the Navy's contractor, PRC. Some studies will provide information on baseline conditions against which consequences of remedial options can be compared, and PRC may also use these data in ecological assessments if the data are of the appropriate quality (that is detection limits, analytes and methods are comparable to PRC data). Remedial alternatives that may be considered in the feasibility study include leaving sediments in place, or the partial removal of sediments. Active remediation options such as capping of sediments in place or in-situ treatment of sediments have also been suggested, and the disturbance of sediments during active remediation and the related short-term exposure pathways during remediation are of concern.

The studies conducted by BERC are not intended to completely define any of the remedial alternatives, but rather are planned as innovative approaches on a limited number of samples to provide an additional level of understanding regarding the intrinsic processes and conditions, and to address some aspects of selected remedial alternatives. This information will be used for the evaluation and selection of the remedial actions under consideration by the Navy. BERC investigators will contribute to those evaluations by the Navy and its contractors as requested. For this set of studies, innovative methods are those procedures and measurements that are not in routine use nor available from commercial laboratories, and which can be implemented using the expertise and sometimes unique facilities available at the University of California at Berkeley (UCB), Lawrence Berkeley National Laboratory (LBNL), and Lawrence Livermore National Laboratory (LLNL)

General Response B: Chemicals of concern and need for site-specific data.

At the time of the preparation of the work plan, the risks associated with specific chemicals present in lagoon or wetland sediments have not been determined by the Navy. Based on limited site data, the chemicals of potential concern as identified by the Navy are metals, PCBs and PAHs, and these chemicals have commonly been of concern in sediments at other sites. While there is literature that generally describes the behavior of these chemicals in sediments, the environmental settings of the Seaplane Lagoon and the West Beach Landfill Wetlands will be unique in terms of depositional history and chemical constituent distribution compared to the literature information. Therefore, a site-specific understanding of how these chemicals are behaving, or may behave in the future, is important for selecting remedial actions - especially if the option of leaving of sediments in place is to be considered.

A number of studies will be conducted by BERC to address topics of geochemistry, toxicity, bioavailability, water flow, and the transformation of chemicals in sediments. A major focus of the studies is to elucidate the processes that currently control the site-specific transformation and transport of chemicals in undisturbed sediment systems. These studies then will help define the extent to which "intrinsic processes" in the undisturbed sediments control the toxicity, availability, or concentrations of chemicals in exposure pathways. Toxicity and bioaccumulation tests will also be conducted, with these empirical data then related to the composition and geochemistry of the pore water sediment. Knowledge of the geochemistry is also important for an evaluation of the potential for release of chemicals should the sediment be disturbed. Other studies related to methane generation in sediment and water flow are important for their implications to remedial options such as capping. This information will be contained in individual technical reports, and then summarized and integrated in a final report to the Navy.

General Response C: Selection of sampling locations, and use of data to estimate nature and extent of chemicals present.

BERC studies will be conducted on samples collected from areas of the lagoon and wetlands that previous studies have shown the highest chemical concentrations, and thus are the more problematic for demonstrating intrinsic processes. Some of the studies will use innovative approaches that will use the expertise and unique facilities of the BERC investigators. Given that innovative methods have more uncertainties than data from more routine methods, it is important that some complementary information also be collected for some samples and methods to better define the sample character, behavior, and consistency among methods. This information then assists in defining the quality of the measurement in terms of the accuracy of the data and what the measurement represents.

The limited sampling locations are not intended to provide data on the nature and extent of chemicals present in the lagoon or wetlands. However, some information collected in the BERC studies is expected to be useful for extrapolation of the data to other locations at the sites. Extrapolations of data will be accomplished by collaboration of the BERC investigators and the users of the study results within PRC and the Navy, within the context of the uncertainties in the extrapolation of the data.

General Response D: The level of detail provided by the BERC studies of intrinsic processes.

In the planning of data collection and uses, it must be recognized that including intrinsic processes as a part of a feasibility study/remedial action selection for sediments requires a somewhat different approach compared to the use of active remediation measures. The most critical differences are that the intrinsic (natural and/or undisturbed) processes are usually less buffered, more spatially variable, and less certainly defined than when active (or externally-induced) measures are applied; the time scale for the intrinsic process is also often longer than for active remediation. Therefore, multiple lines of evidence are important to conclusively demonstrate that the intrinsic processes are occurring and to determine the rate-limiting processes. Such demonstrations usually require monitoring of several site-specific parameters and conditions that are used in the context of conceptual and mathematical models, and which together support the conclusion that the natural (intrinsic) processes are occurring. While such activities might otherwise be regarded as a characterization effort, they have direct relevance to the issues of treatability of the sediments, or the consequences of imposing certain sediment management techniques. The evaluation of intrinsic processes as part of a remedial plan are then distinct from active remediation processes where external sources are used to enhance or overwhelm a natural condition, and where responses to the changed condition can be unambiguously determined (for example, a proportional chemical concentration decrease in response to applied enhancement.).

General Response E: Statements of data quality objectives.

Data quality objectives (DQOs) are critical to obtain data that are acceptable for their intended uses in ecological assessments or feasibility studies. As discussed above, the BERC studies primarily will rely on innovative methods to evaluate intrinsic processes in sediment systems. Such innovative methods have less experience from which to predict method performance, and this limitation includes the effects of matrices, outside interferences, and possibly other environmental variables (temperature, water quality, etc.). With regard to estimating rates of intrinsic processes, the rate of a process is a function of these natural (intrinsic) properties of the system and which are always site-specific. To provide data that meet the intent of the DQO process, the studies to be conducted by BERC will be subjected to a thorough review process that includes independent reviews by the Principal Investigator and the Contractor Quality Control Program Manager (CQCPM), a meeting of selected experts to critically review data and results, and a peer review of written reports conducted by the CQCPM. These quality control and quality assurance steps will then provide data of the highest quality for an informed use by the Navy and its contractors in the decision-making process.

Response to Comments of PRC

General Comments

Some issues raised by PRC are discussed in the General Responses A and D above. The bulleted items at the end of PRC's General Comments nicely summarize some of the information that will results from the proposed studies.

With regard to organization of the Work Plan, it was written anticipating an audience with different interests. Section 3 was intended to be an overview of the studies, with Sections 4 and 5 providing the more technical information. The Standard Operating Procedures (SOPs) are intended as stand-alone documents for use in the laboratories and in the quality assurance/audit process. Combining Sections 3 and 5 along with the SOPs would provide a more integrated presentation of the technical topics, but the length and technical detail for each topic area would have been more difficult to understand for most readers. Responses to two additional comments provided by PRC are given below.

2nd and 3rd paragraph: "The Treatability Study Workplan....does not provide typical" "Two treatability studies are included in the Intrinsic Workplan....."

The Workplan provides advanced characterization methods and analyses to address intrinsic processes operating in sediment systems, and which are not based on an externally-controlled technology (please see General Responses A and D). Success or failure treatability criteria for a method are then not defined in this Workplan because the effort is directed at quantifying the naturally-controlled, ongoing, processes of burial (sediment deposition), transport, and transformation. The data to be generated will assist in answering questions related to current and future exposures associated with in-place sediments.

Page 1, 4th paragraph: "Treatability studies do not need to include the detailed information....A brief statement of the problem....."

BERC heartily agrees with this comment, and future Workplans will minimize inclusion of detailed data from earlier studies.

Specific Comments

Table 2-6: "The PRC data in Table 2-6....The text and table are unclear...."

The correction that the data are for 28-day laboratory bioaccumulation tests and did not use organisms from site will be included in the text.

Figure 2-8: "This figure represents monitoring wells and boring locations.....This may be an error in references."

The reference did not intend to suggest that the monitoring wells were installed by E&E, but only that the wells were cited in the E&E document.

Page 2-3, Sect. 3.7, page 3-9, 1st paragraph: "Can the Pb-210 profiling distinguish between sediment....."

The Pb-210 technique measures only the radioisotope concentration for a sample, and not the source of the sample. However, using grain size analyses of the 2 cm slices every 20 cm in the core may permit resolution of outfall sands compared to silts and clays contributed by San Francisco Bay, and this information along with chemical analyses may be interpreted as to sources.

Page 3, Sect 3.7, page 3-9, 2nd paragraph: "....there is most likely an upward groundwater gradient in the Seaplane Lagoon."

The scope of the Workplan relates to measurement of the intrinsic processes of fluid exchange through Seaplane Lagoon sediments, which will then quantify the suspected gradient. Piezometers

placed perpendicular to the north seawall of the Lagoon will assess the fluid flow and its variations in one transect of the Lagoon. Unless PRC data show that the Merritt Sands are consistent and reasonably homogenous under the lagoon, we will not be able to assess fluid exchange and gradient throughout the lagoon.

Page 3, Sect. 3.7, page 3-9, 3rd paragraph: “(A) Tidal influence cannot be determined with slug tests. (B) It has already been determined....”

Slug tests will be used to determine local hydraulic conductivity. BERC’s main focus is to establish quantitative water fluxes from the landfill to the wetlands, and the influence of tidal fluctuations.

Page 3, Sect. 3.7, page 3-10, 1st paragraph: “It has already been determined that the seawall does not prevent hydraulic connection....”

The TDS data and tidal influence in the monitoring wells is not quantitative information for assessing water flow dynamics. The focus of BERC studies is a water balance for the wetland to determine water flows and exchanges with the Bay and the landfill. Accurate water level measurements in the wetland are a non-invasive and simple tool that should rapidly indicate seepages are significant for contaminant transport.

Section 4.0, Page 4-1, third paragraph: “The text states that initial cores will be examined to “confirm that the cores are representative of expected site conditions”.....”

The sediment core can be viewed through the transparent polycarbonate liner. Based on the acoustic imaging results and recent borings in the lagoon by PRC’s subcontractor team, the recent sediments overly the Merritt sands. The recent sediments are an olive green in color, and the Merritt sands are a yellow brown. Any other colorations or obvious layers would be evidence of heterogeneity that would be of concern for the representativeness of the sediment samples.

Section 5.3.1.1. Page 5-12 and SOP 25.3: “The porewater extraction method involves centrifuging the sample.....the text in Chapter 5 and the SOP indicate that centrifuged samples will be filtered.”

The sample will be passed through a 20 micron Nitex mesh to remove organisms (predators) that may interfere with the toxicity testing; this procedure is not intended to be a filtration to control particulate size. BERC prefers to collect the pore water as the supernatant from centrifugation of samples at 2,500 g. This procedure is that used in past testing procedures on SF Bay sediments by the LBNL/LLNL team, and because it is used in the State Water Resources Control Board’s Bay Protection and Toxic Cleanup Program throughout California. The toxicity data from BERC can then be compared to this database.

Sect. 5.5.4, page 5-29, 1st and 2nd paragraphs: “While the text does not state that the culvert will be blocked during this study, it is implied.”

While blocking the culvert for a 48 hour study period would have been relatively easy and not disruptive, the plan as stated is to undertake water level monitoring following wetland recharge by a high tide without blocking the culvert.

Section 5.6.1. Page 5-30, second paragraph: “Please remove the reference to Seaplane Lagoon dredge material.... placed in ... Wetlands.”

The reference to dredge material being placed in the wetlands will be deleted from the text because there is no documentation of this occurrence.

Sect. 5.6.2, page 5-37, 2nd paragraph: "The text states, "The carbon isotope ratio data from these studies will demonstrate whether intrinsic biotransformation....If this technique is capable of determining whether or not biodegradation is occurring...."

Microbial processes will be assessed with a combination of measurements that provide complementary lines of evidence that intrinsic processes are occurring. Carbon-14 is useful for distinguishing recent versus aged organic matter, carbon-13 is a very sensitive indicator of microbial isotopic fractionation compared to inorganic reactions, and carbon dioxide and methane provide additional evidence of microbial transformation pathways associated with carbon transformation.

Section 5.6.6. Page 5-42: "this study should be conducted in containerized plots and not in the native soil... of the site"

The studies to assess the rate of transformation of chemicals in soil were designed to most closely simulate actual processes in the field, including seasonal influences (weather, plant growth, etc.). The experimental approach has been revised to contain the soil in a lined container in the ground, and with a leachate collection system to capture percolating water.

Removing the soil into the laboratory has complications in that seasonal influences must be controlled using artificial light, water cycles and other measures, thereby increasing costs as well as adding uncertainty to the extrapolation of the data to actual environmental conditions. It is also must be recognized that experiments on a laboratory scale are of a limited size, and that such limitations impose severe constraints on the processes that would occur in natural systems; stated another way, laboratory microcosms often reflect the influence of system boundaries rather than the influence of the unrestrained natural system. In an obvious example, the growth of plants native to NAS Alameda is difficult in a confined laboratory setting, and therefore the results of the laboratory study will be difficult to extrapolate the field conditions.

SOP 25.1: "Sediment collection techniques assumes the use of a boat.....southern pond is dry and the northern pond...."

A boat will not be used for sediment sampling in the wetland area because of the shallow water expected. However, the sediment cores will be collected using same "push" coring method by wading into the shallow water and then placing of the corer into the undisturbed sediment.

Additional Comments: "If BERC is planning to sample before the rainy season,....If sampling is to be conducted after the rainy season..."

BERC has requested that PRC select the sampling locations for the various BERC studies so that the results will be maximum value in PRC's risk assessment and feasibility study efforts. While BERC has the expertise to conduct the proposed studies, PRC has a better perspective on what site locations and concerns are of paramount interest to the Navy.

Response to comments of Ned Black, US EPA

1. Page 3-8, last paragraph of Sect. 3.6: "more information.....used to evaluate equilibrium partitioning."

The model is described in Sect. 5.4.3 Sediment/Water Partitioning Equilibrium and is based on empirical correlations that utilize information on sediment organic carbon fraction and the chemicals' octanol-water partition coefficient. Direct measurements would require development of sediment partitioning procedures, phase separation procedures, and analytical organic chemistry methods that are time consuming, but that do have literature precedent. It should be particularly noted that partition coefficient measurements for hydrophobic chemicals (PAHs, PCBs) are highly susceptible to removal of the finer particulate, and such data can be regarded as being operationally defined by the experimental procedure; it is BERCC's judgment that the empirical correlations are sufficient for the requirements of the Navy.

2. Pg. 3-11 last paragraph of section 3.8: "Will field spikes of PCBs be necessary?"

It is not planned to do field spikes of PCBs because of the expected recalcitrant behavior and toxicity of some PCB congeners, and associated waste disposal of the soils.

3. Pg. 5-1 Section 5.0. "This section would be easier to read if the individual project...."

Rather than revising Section 5 to include the SOPs, a table relating SOPs to the sections has been developed for easy reference (Table 5-3).

4. Page 5-7 to 5-8, Sect. 5.2.4: "Drying and subsequent handling will not affect the chemical state...."

The sediments will be freeze-dried and not exposed to air during handling procedures. The sediments will be handled in an inert atmosphere and be stable to any changes once the water is removed from the sediments.

5. Pg. 5-14, Section 5.3.2: "the Workplan should make clear that the depths of the 0-, 1-..."

This clarification will be made in the text.

6. Pg. 5-40, Section 5.6.4: "Will the reactors be sampled anaerobically?"

The reactors will be "sacrificed" for sampling, thereby destroying the anaerobic character of the system. The concentrations of the PAH and PCB constituents of concern are stable to oxidation at ambient conditions and are not expected to be affected by the system becoming aerobic; the constituents will be extracted for analysis within the prescribed holding times.

7. Appendix B, SOP 26.3, Sediment Bulk and Mineralogical Analyses, Section 5.2. "Oxidation can take place in the absence of water. ..."

The samples will be prepared in an inert atmosphere. Additionally, spontaneous oxidation of sediment samples in the absence of water is not expected to be important process

8. Appendix B, SOP 30.3, Intrinsic Transformation of PAHs and PCBs in Anaerobic Sediments, Section 5.0. The third gas is hydrogen, and the gas mixture should be listed as 85:10:5 of nitrogen, carbon dioxide, and hydrogen. Finally, as discussed above the reactors will not be sampled anaerobically as the chemicals of interest (PAHs and PCBs) are not particularly sensitive to exposure to air.

Response to Comments of Barbara Johnson, NFESC,

General Comments

“...from the Navy’s perspective, the usefulness of the data, in terms of the Navy’s objectives, has not been adequately described.”

Please see the General Responses A, B, C, D and E that address many of the comments from this reviewer. Some of the reviewer’s comments on Sections 1 and 3 requested more detail than was planned for these sections. Section 1 was only meant as an overview of the project concept and history. As the section title states, Section 3 was only intended as an overview of the project and its component studies. Sections 4 and 5 provide more technical detail, and the SAP (including the SOPs) provide specific procedural details. In response to provide a more explicit connection between the measurements and data uses objectives, Table 5-3 has been prepared.

Specific Comments

Page 1-1, Para. 1. (Section 1.0) “The study will evaluate whether intrinsic processes are transforming or immobilizing chemicals released by past operations into sediments at Sites 2 and 17.....”

Please see items A and E in the General Responses. Section 1 is an Introduction section that is intended as a very general presentation of the project origin, organization and general purpose. The statement quoted is one general purpose of the project, and these data may be used by the Navy in remedial action selection. Given the innovative nature of the measurements and the intrinsic nature of the processes being investigated, it is yet unknown as to specific utility of the data, but the methods do have considerable promise to provide a more complete understanding of site conditions. However, BERC and its investigators will not be directly involved in the selection process.

Page 1-2, Para. 3. (Section 1.1) Study will also estimate rates at which chemicals are likely to move from sediments into surrounding waters under disturbed conditions....”

Please see General Responses A and C. The studies are intended to support the evaluation of a number of technologies, and no study or set of studies by BERC will be complete to solely support a technology selection.

Page 1-3, Para. 2 (Section 1.2) “States DO 4 authorizes for Site 17:...”

The DO does not specifically address the purpose of the study or the end use of the data. Please see item A in the General Responses regarding the purpose of the proposed studies.

Page 1-3 to 1-4. “Lists data to be collected by the various participants - how do these tasks relate....”

The tasks cited on page 1-2 are only general descriptions of the types of studies to be performed, and the activities at the individual facilities are listed for general information. The actual persons responsible for specific studies are listed elsewhere in the Work Plan (Section 9, Project Management). It should also be recognized that PRC is responsible for preparing the Site Investigation/Feasibility Study reports.

Page 1-4, para. 1 (Section 1.3): “States low levels of contaminants are due to intrinsic remedial processes...”

It is not intended to suggest that the low levels of chemicals in sediments are due to previous transformations, only that the concentrations are possibly low enough that such that there are no toxic effects that would prevent transformation reactions (the word “continue” will be deleted to clarify this issue.) With regard to dredging, the lagoon is reported to have been dredged once, and the sediment layer of major interest is believed to reflect deposition since dredging. With regard to metals, the statement regarding speciation is based on general sediment chemistry that needs to be

determined for this particular site; however, it is believed that some metal in a particulate form (particularly as paint chips) have entered the lagoon.

Page 1-4, para. 2 (Section 1.3): “This paragraph now implies the purpose of this study is to evaluate sediment remediation options,....How will data from this study be used to evaluate remediation options?”

As discussed above in General Responses A, B, C and D , the results of the BERC studies will be used in the screening and selection of remedial options, including that of considering intrinsic processes to be part of an limited or no action alternative. The Navy has specified that Sites 2 and 17 are of interest for these studies, and that PAHs, PCBs and metals are of concern. As discussed above, the results of the BERC studies will be used by the Navy along with the data of PRC to evaluate and select the remedial option.

Table 1-1: “Who’s SOPs/SQPs are these - that needs to be identified....”

The SOPs and SQPs listed are those of BERC, and are part of the Contractor Quality Control Program Plan. They can be obtained from the BERC office. The SOPs prepared for this project are located in the SAP, and will be the basis for the QA/QC audits.

Page 2-5, para. 2 (Section 2.2.1). “Reference to Figure 2-6 the Sewer Outfalls are not labeled...”

The outfall are designated by letters of the alphabet, and only the outfalls of interest to the lagoon are listed in Figure 2-6.

Page 2-8, para. 1 (Section 2.2.3) “Was the lagoon ever dredged?...”

Information on dredging activities in the lagoon is unsure, and this information and other historical information is summarized in PRC reports. The proposed studies by BERC and other investigations by PRC will develop the information for evaluating the potential remedial options.

Page 2-8, para. 4 (Section 2.2.4) “...refers to this as a treatability study, but according to Section 1 it is not....”

As discussed in items A and D in the General Responses, the characterization of the intrinsic processes is being conducted in the context of use the data in a feasibility study.

Page 2-12, para 4 (Sect. 2.2.4.2): “This is the first mention of radiation measurements to be taken. Why were measurements taken?”

The text refers to data collected by others prior to the initiation of the Workplan, and was included only to describe site conditions. An evaluation of the nature and extent of any radiation-related materials is not in the scope of studies to be conducted by BERC.

Page 2-15, first line “Are any US Federal rare, threatened or endangered species present?....”

The reference should be to Section 2.3.3; BERC notes that Section 2.3.2 does not exist. PRC is responsible for the evaluation of ecological issues and therefore PRC should be contacted regarding and at-risk species or habitats. All work in the wetlands will be cleared through the base biologist.

Page 2-15, para. 2 & 3 “References previous studies/investigates done, ...”

The information is cited to describe the conditions at the site. As discussed in items A and D of the General Responses, the BERC studies will use innovative methods to elucidate how intrinsic processes control site conditions, and this information will be used by the Navy in the evaluation of remedial options.

Page 2-16, top of page “References Figure 28...”

The reference should be to Figure 2-8.

Page 2-16, para 1 & 2 “Findings of PRC-conducted SWAT not presented.....”

The SWAT is mentioned in a historical perspective, and the data from the PRC studies have been used in planning the proposed work.

Page 2-17, last paragraph “What is the source of this data - who’s study?”

As cited in the referenced figures, the 1992 tidal influence studies are reported in the 1994 PRC SWAT study (1994b in reference section).

Page 2-19, para. 4 “Again, refers to this as treatability study - conflicting with Section 1.”

Please see items A and D in the General Responses.

Page 2-19, para. 5 “Refers to data summary tables - which tables and where are they?”

The summary data are contained in Tables 2-12 through 2-16.

Page 2-20 para. 2, 3, & 4 Reference the study - name of study, who did, and date.”

As introduced at the beginning of Section 2.3.5, the references for the ecological assessment and the SWAT investigation are PRC 1994a and PRC, 1994b, respectively.

Page 2-21, para 4 (bullet 4) “Radiation levels need to be compared to naturally.....”

The issue of radiation is not within the BERC scope, but is provided for information only.

Page 2-22, para. 1 “Reference for ecological study - who did and when?”

As introduced at the beginning of Section 2.3.5, the references for the ecological assessment and the SWAT investigation are PRC 1994a and PRC, 1994b, respectively.

Page 3-1, para. 1: “work plan for site characterization and treatability study with objectives listed....”

Please see General Response A. The opening text of Section 3 has been revised to incorporate some information contained in the General Responses above. The objectives are the three main categories in which data from the proposed studies may be used. Section 3 was written so that the lay reader could understand the purpose of the studies. As indicated by the heading for Section 3 (“Overview of Proposed Project ...”), this section was intended to inform the reader as to the overall scope of the proposed work and to be less technical.

Page 3-1, para. 3: “Acoustic imaging to define stratigraphy is difficult is two such similar materials....”

The information from the acoustic imaging task will be compared to the boring log data from PRC.

Page 3-1, para. 4: “ develop data to simulate.....sediment disturbance. Is this referring to developing a computer.....”

A computer simulation model will be used to verify pore water chemistry; this model will also be applied to some hypothetical disturbance scenarios and compared against the disturbance toxicity tests. However, the text that states that the “expertise of ... staff.. will develop data ... simulate ... chemistry and toxicity ...” refers to experimental design and interpretation of the data. The disturbance studies are planned as extensions of the sediment geochemistry and toxicity studies where only the water/sediment exchange variables are modified beyond the natural conditions.

Page 3-2, top of page: "Implies this is an experiment using methods at a few selected locations..."

Please see General Responses A and C.

Page 3-3, para. 1: "States Navy sources contributing to metal load is not known....."

These questions are not within the BERC scope, and PRC is currently preparing the RI report.

Page 3-3, para. 3 (Section 3.2): "Another statement of purpose of study - assess speciation, toxicity and natural processes...."

Please see General Response A. Also, Figures 3-1 and 3-2 present a more complete summary of the scope of the proposed studies.

Page 3-4, Section 3.3 to 3.9: "How do these tasks and their results relate to objectives....."

Again, please see General Response A and the individual study descriptions in Section 5; Table 5-3 also relates the tasks to data use objectives.

Page 3-4, para. 2 & 3: "What about shallow water effects and echoes off sea walls...."

These are effects that the investigator must assess in the field, and will be discussed in the report for this task.

Page 3-4 to 3-12 (Section 3.3 to 3.9) "Need to identify/relate these tasks to objectives, to DQOs, show how data will be used..."

Please see Table 5-3 referenced in the beginning of Section 5.

Page 3-7, para 1: "To compare toxicity....."

The toxicity will be measured in pore water and in the SWIC system, and any increase in toxicity in SWIC system will be attributed to contact with sediment.

Page 3-8, para 3 (Sect. 3.7): State "The data for evaluating chemical transport in sediments will be obtained from measurements on sediment cores. What measurement, how done?"

Page 5-26, Sect. 5.5.2 describes the measurements to be conducted. Additionally, the evaluation of geochemistry in the sediment layer will also help an assessment of the movement of constituents in the sediment.

Page 3-9, para 1: "The measurement of sediment properties as described are standard tests....why do they need to be run at a research lab?"

Soft poorly consolidated sediments are very difficult to characterize using standard geotechnical testing techniques and must be conducted under expert supervision. The UC Berkeley Geotechnical Engineering Laboratory pioneered in the development of such tests and has the expertise to conduct the measurements. Consolidation tests will determine hydraulic conductivity as well.

Page 3-10, para 1 (Section 3.8): "The last sentence refers to a remediation alternative - sediment capping. "

Please see General Response A and Section 5; Table 5-3 presents a summary of how the data from the various tasks may be used in remediation planning.

Page 3-12, para 1 & 2 (Section 3.9): “How does this task relate to tasks in Sections 3.5 and 3.6?”

The tasks to investigate disturbed sediment scenarios are considered as straightforward and complementary extensions of the geochemical and toxicity measurements performed on the undisturbed systems. These tasks will provide some comparative information on the resulting effects if the sediments are slightly disturbed (such as by prop wash, dredging, etc.)

Figure 3-1 and 3-2: “This information needs to be related to the stated objectives.....”

Please see table 5-3 in Section 5.

Page 4-1, para 1: “....expected lateral heterogeneity of samples....implies a computer model will be developed....”

The Workplan has outlined a limited sampling effort but a detailed characterization of those samples with depth. The lateral extent of contamination will not be determined in this effort and models will not be developed to apply site wide. However, the Navy, PRC and BERC may extrapolate information from the modeling if all agree that such data uses are appropriate. BERC reports will clearly state the basis for any such extrapolation of results.

Page 4-1, para 2: “Establishing accurate depth profiles of chemical distribution, chemical speciation,.....Under which task and with which test/analysis will the information be gathered?”

This information is discussed in Section 5, and is summarized in the tables in Section 5. The comment on collecting contingency samples is appreciated, and while some contingency samples will be collected BERC believes that most sediment cores should not have holding times of more than a few days for most of the planned measurements (particularly, geochemistry, toxicity, and physical testing).

Page 4-3, para 3: “Soil gas testing - which task in Section 3 will this fall under?”

The soil gas measurements refer to Section 3.8 where the isotope ratios of carbon dioxide and methane will be measured for evaluating the transformation processes.

Section 5: “How do these test/analyses descriptions relate to tasks in Section 3?”

Please see Table 5-3 in Section 5.

Page 6-1, para 1: “Project objectives stated as....determine toxicity and migration....establish the time course...evaluate the impacts...”

These are some of the uses of the data, and the measurements and uses of the data are summarized in Table 5-3..

Page 6-1, para 2: “....and organochlorine pesticides and trace metals.”

Pesticides will not be studied due to analytical costs. References in the Work Plan to pesticides will be deleted so as to avoid the appearance that pesticides will be studied.

Page 6-1, para 3: “Last sentence says “...sediment ingestion..” is “ingestion” intended, could direct contact also be a factor?”

Direct contact of sediments with benthic organisms might be a route of exposure.

Page 6-2, top of page: “What, if any, “special precautions” can be taken?”

Special precautions refer to the possible use of a silt curtain during dredging compared to confinement by sheet piles. Silt curtains might contain turbidity plumes while sheet piles would confine movement pore water and resuspended particles.

Page 6-2, para 1: "Last sentence does not make sense..."

Disturbance of contaminated and uncontaminated sediments can cause toxicity if pore water contains elevated levels of hydrogen sulfide or ammonia, or if the disturbed sediments are oxidized and release metals.

Page 6-2, para 2: "How will this information be used to help select a remedial technology?"

A major purpose of the studies is to assess in situ sediment toxicity and evaluate the need for remedial technologies.

Page 6.2, para 2: "Assuming there has been no disturbance of the sediment profile...."

Acoustic imaging preliminary results suggest a layered structure in the Lagoon sediments, indicating a quiescent depositional environment.

Page 6.2, para 3: "field scale water flow studies....Which task in Section 3 does it fall under?"

This is mentioned in Sect. 3.7, Transport Processes Assessment, page 3-9 and expanded on in Sect. 5.5.3. Measurement of Seepage Fluxes in Seaplane Lagoon (page 5-28) and Sect. 5.5.4, Tidal Influence Study in Landfill Wetlands (page 5-28).

Page 6-3, para 3: "intrinsic remediation of fuel HC in relation to study of PAH's and PCB's"

Pages 2-10 and 2-12 discuss TPH data in sediments, page 1-4 refers to the need to include analyses for fuel hydrocarbons "because they influence the rates of transformations of chemicals and they influence the mobility of both metals and other organic chemicals." Sect. 5.6.1 is on Fingerprinting PAH's, PCB's Hydrocarbons, and Hydrocarbon Tracers (page 5-30). Data will be used to understand the sediment matrix and provide a more complete picture of sediment organic matter.

Page 6-4, para 1: "Since 'lateral heterogeneity' is expected, how can the assumption be made...."

Intrinsic bioremediation rates will be assessed at the location where data is collected and not extrapolated for the whole Seaplane Lagoon or wetlands area unless the Navy, PRC, and BERC agree the data are consistent across these areas and the extrapolation is appropriate.

Page 6-5, para 1: "estimates of consolidation, is this the same as 'compressibility'?"

These are referring to geotechnical engineering consolidation tests.

Table 7-1: "These DQOs are very generic, not appropriate at this stage of the effort."

Please see General Response E and Table 5-3. Data quality will be reported so that PRC may fully understand the application and limitations of the data.

Page 8-1: "The reports need to be related to the DQOs and present studies and results....."

The data uses are summarized in table 5-3. BERC will retain copies of the data for a period of time agreed upon with the Navy, and the original data will reside with the lead investigator for the task. Individual reports for the tasks and a final summary report are the deliverables for the project. The data collected in the various studies will be of a different type than usually obtained in more routine investigative approaches, but will be completely reported so that Navy may manually compose a database.

SAP: “For the SWIC, under Specialized Equipment, a reference is made to the Work Plan Section 5.3.2.....”

A figure was left out of the SOP 27.2, and will be provided to the Navy.

SAP: “There is nothing on the soil gas test...”

The soil gas collection procedures have been developed previously and applied in the Intrinsic Biotransformation Treatability Study.

SAP: “The relationship of the contents of the SAP, Section 5 and Section 3 of the Work Plan needs to be explained.....”

As discussed above, Section 3 was intended as an overview of the studies, and Sections 4 and 5 provided more technical details. The SAP, including the SOPs, provide procedural information in the context of a treatability study and will be the basis for the QA/QC audits.

HSP: “ The HSP is good;...”

The preparation of the HSP has benefited from previous projects

HSP: “No mention of protective requirements for samples....”

PRC has previously found no radioactivity of concern and handled samples in the customary manner.

Responses to comments of Gregory S. Durell, of Battelle Ocean Sciences

General Comments

(2nd Paragraph, page 1) "...data generated in these studies directly used in the decision making processes."

Please see General response A. A table listing the measured data and data uses has been prepared and is included in Section 5 of the Work Plan. While all of the methods are based on scientific principles and all data will have some potential application to understanding site conditions and/or evaluating remedial alternatives, it is realized that some data will have more value than others in the decision making process. Such data could be obtained in a phased program, but the time is not available for a phased approach, and the apparent cost savings may be offset by the remobilization and resampling activities. As discussed elsewhere, BERC is not preparing the feasibility study or the risk assessment, but a final report will be prepared for the delivery order. This report will compare and integrate the data collected from the different studies, as appropriate, as it pertains to the evidence for intrinsic processes that control site conditions, and for implications of study results on several potential remedial alternatives. This report will be used as a resource by the Navy in the preparation of the feasibility study.

(3rd paragraph, page 2) "...rates of degradation and mobility of PAH, PCB, ... described in the scientific literature..."

Please see General Response B. The transport and transformation processes for various chemicals are generally described in literature, but some NAS Alameda, site-specific determinations are important for understanding the site-specific behavior of these chemicals, especially if leaving sediments in place is a remedial option. The previous dredging of bay mud to expose the Merritt Sand strata, the more recent (40 years) accumulation of sediments on the Merritt Sand is the semi-enclosed lagoon, and the potential upward gradient from Merritt Sand into the lagoon, are sufficient reason to warrant evaluation of the site-specific behavior of PCBs, PAHs, and metals. Similarly, the current use of the wetlands area as a wildlife habitat is reasonable sufficient concern for the long term behavior of chemicals in this area. BERC believes that the further investigation of the extent of chemicals present in the wetlands is disruptive of the wildlife and expensive, and unnecessary if the advanced and site-specific information obtained in the BERC studies and PRC's assessment is used in the decision making process to determine that chemical concentrations are acceptable, and that intrinsic processes will continue to mitigate chemical exposures at the site.

(1st paragraph, page 3) "Proposed Studies Should be Questioned ..."

Please see General Responses A, B, C and D. The proposed studies using innovative methods have the potential for providing important information that will add confidence to understanding conditions at the sites, and which will then provide a better basis for decision making - especially with regard to remedial approaches that will leave some or all of the sediments in place. All of the methods proposed are based on scientific principles with some literature precedence. It is recognized that site conditions (matrix, differing concentrations) may limit the success of the applied methods, and the expertise of the investigators will be critical for evaluating the accuracy and representativeness of the data. The investigators, through the Principal Investigator at UCB who will be preparing the Final Report, will also be available for consultation in the application of the data to any Navy-specific data uses.

Specific Comments.

"Section 1.3 Intrinsic Sediment Processes Study Decision Process."

BERC agrees that PCBs are not a class of petroleum hydrocarbons, and a comma should have followed the ("PAHs") so this entry would have read correctly. The relative importance of biogenic and petroleum-source hydrocarbons in controlling the mobility and transformation of

chemicals in sediments is dependent on their relative concentrations, and the presence of petroleum hydrocarbons is particularly of interest when outfalls are believed to have been the source of chemical discharges to the lagoon.

Section 3.3 "Physical Characterization of Sediment. ... information appears to have been generated ... redundant work is not performed."

The properties of the sediments collected for the use of innovative methods will be measured, and not be redundant, because these properties are useful for characterizing the sediment samples being studied, and for possible extrapolation of the innovative data results to other sediments when the properties are comparable.

"Section 3.4 ...3.8 Various pore water and sediment processes studies. ...level of detail not needed."

As stated in Gneal Response D, the level of detail for these studies is important for understanding the site-specific conditions. While the literature is useful for supporting the site-specific conclusions regarding the intrinsic processes at NAS Alameda, it is the site-specific information that is required for Navy, the regulatory agencies, and the public to have confidence in the remedial strategies selected, especially if the strategy includes leaving some sediment in place.

"Section 4.0 Sampling Approach. ...sampling approach ... not ... well developed."

As discussed in General Response C,, the sampling approach is limited to the areas of the highest chemical concentrations. Depending on the results of the studies and conditions in the lagoon and wetlands, the results of some studies may be usefully extrapolated to other locations. It is also recognized that additional sampling and methods use may be necessary depending on the results, the use of the information, and the acceptability of the uncertainty in the extrapolations. However, there is no basis for extending the sampling or expanded use of the methods at this time.

"Section 5.0 Method and Analyses"

The comments of Dr. Neff are addressed in the following section.

Section 6.0 Integration

The data to be measured and the potential uses of the data are summarized in a table to be added to Section 5. Section 6 discusses how the data are complementary and can be used to address the issues of chemical concentrations in migration pathways, the occurrence of intrinsic processes, and some possible aspects.

Responses to comments of Jerry Neff, of Battelle Ocean Sciences

Paragraph 1: ".....how much of the information can be used effectively for risk assessment and for making decisions about site remediation and cleanup."

BERC believes that all of the information collected in the proposed studies can potentially be useful in the context of the decision process. However, the effectiveness of the use will depend on the accuracy and precision of the data, which is somewhat dependent on the matrix and associated interference, and the significance of the decision. For example, a strategy to remove the uppermost sediment layer would be significantly supported by a well defined deposition pattern (Pb-210), and conclusions that the sediment layer possesses unacceptable toxicity (toxicity tests, TIE, geochemical constituents.) However, multiple lines of evidence - no matter their strength - all must support the decision process.

Page 5-1. "Do you anticipate having to dredge...what is the reason for core samples from a depth of 2 m?"

Dredging is one option that would be considered as part of the Feasibility Study. It is therefore important to understand the depth of any contamination. It is probable that the chemicals present in the deeper sediment are not mobile, and some studies are intended to assess this condition for site specific conditions.

Section 5.1.1 Acoustic Imaging. "The purpose of this study is unclear...contaminants in subtidal marine sediments are unlikely to migrate...."

Acoustic imaging will provide information on the depth of recent sediments that would be considered for dredging in one remedial option, and the information has been useful in planning of the depths of PRC's and BERC's sampling efforts. Additionally, acoustic imaging has revealed that a young bay mud strata is not present in the lagoon, and was apparently removed during an earlier effort to dredge the lagoon.

Sect. 5.2.1: "Microelectrode Measurement in Sediment Core Pore Waters. ...unproven method. ...if validation experiments are performed ... method used on trial basis."

The use of the microelectrode is a scientifically sound procedure, and is one approach to assessing the site specific redox conditions of the sediments. Given the alleged activities that discharged chemicals into the lagoon, site specific data rather than literature precedent is preferable for remedial decisions at NAS Alameda. The microelectrode measurements will be compared with complementary data from extracted porewater analyses as well as from geochemical modeling efforts.

Sect. 5.2.2 Pore water constituent measurements. "Can pore water samples be collected, squeezed, and analyzed....?"

As discussed above, site specific decisions require some site-specific data, and these data are needed to identify redox zones and that can't be predicted from data collected at other sites. Porewater collected from the squeezer will be tested for its any disturbance of the redox profile by comparison of constituents, the microelectrode measurements, and validated by geochemical modeling.

Sect. 5.2.3: Sediment Bulk Mineralogy and Chemical Analysis.

The analyses are needed for a more complete picture of sediment mineralogy and geochemistry. Given that lead is present at a concentration of 3 g/kg and there is an apparent layering of chemical concentration at the sampling locations, this sediment not be like other more natural locations. These data are also important for more completely describing sample quality in the possible application of the method or comparison of geochemical data with information from other sites where the Navy is evaluating remediation alternatives.

Sect. 5.2.4 Sediment Metal Speciation Analysis

Arsenic and mercury will be analyzed by ICP-MS. Modeling efforts are important for integrating analytical data and site conditions for understanding current conditions associated with toxicity and the bioavailability of chemicals, and estimation of conditions should the sediment be disturbed.

Section 5.3.2 Sediment/Water Interface Corer (SWIC) Test. "... best way to evaluate the toxicity of these deeply buried sediments? ..."

BERC believes the SWIC test is an appropriate way to test the toxicity of these sediments which may be exposed to aerated water (oxygen) should the upper layers of sediment be dredged as part of a remedial action. It is preferable to pore water toxicity testing because the pore water will undergo oxidation processes during the conduct of the test and not reflect oxidation processes associated with sediment (such as metal releases).

Section 5.3.3 Pore Water Toxicity Identification.

The salinity of the water samples will be evaluated as part of the toxicity testing and TIE.

Section 5.3.4 Acid Volatile Sulfide and Simultaneously Extracted Metals.

This limitation of the AVS/SEM test is correct and noted.

Section 5.4.1 Bivalve Bioaccumulation.

The test will not include analyses for metals because of cost limitations.

Sect. 5.4.2 Digestive Fluid Extraction

Chemicals solubilized by digestive juices from sediments represent the maximum amount of chemical that is bioavailable. The purpose of this side by side comparison with clam uptake test is to further evaluate if this test is faster, cheaper, and as accurate as the bivalve bioaccumulation test.

Sect. 5.4.3: Sediment/Water Partitioning Evaluation

Comment noted and we are in agreement with the points made.

Sect. 5.5.3: Measurement of Seepage Fluxes in Seaplane Lagoon

The purpose of this study is to assess fluid flow through Seaplane Lagoon sediments and determine if flow is significant in causing contaminant exchange with the water column. This information is also important for evaluating the capping alternative.

Sect. 5.6.4 and 5.6.5: Intrinsic Transformation of PAH's in Anaerobic Lagoon and Wetland Sediments, and Constraints on Microbial Transformations of PAH's and PCB's in Lagoon Sediments.

Laboratory experiments are needed to bracket the rates of biotransformations and understand constraints so that comparison is possible between in situ rates and laboratory studies. While the literature data are valuable for a general understanding of chemical behavior in sediments, the proposed studies are important for addressing the site specific question of how long the PAHs or PCBs may persist if the sediments are undisturbed, and what conditions promote the transformations.

Sect. 5.6.6: Transformation of PCB's and PAH's in Vadose Zone Soil Plots.

There is confusion as to the site; the soil is upland of the wetland and a vadose zone does exist. No risk assessment has been conducted regarding the chemicals present, but the issue of whether intrinsic processes are occurring to further mitigate any risk is still usefully addressed at this time. Homogenizing the soils as part of the experimental design does compromise the true in-situ quality of the soils, but is necessary to avoid an extensive sampling effort and statistical analysis to address the potential heterogeneity of chemical concentrations.

Summary

The comment suggests that models are available for chemical release and transformations in marine sediments. BERC's approach is to examine those conventional assumptions using advanced tools for chemical, physical, and toxicological characterization. BERC realizes that all tools may not be needed for the characterization and remediation assessment at future sites, and the application of the data to NAS Alameda conditions will show which approaches and methods are the most useful and persuasive. The proposed studies do provide a state of the art evaluation of specific NAS Alameda conditions. This high level of definition is particularly important when "no action" or minimal active remediation alternatives are being considered.

Responses to comments of Jim Leather of the Navy's Environmental Sciences Division, San Diego, CA

Pg. 1-2) "The workplan is proposed to address intrinsic processes..."

The possibility of doing the measurements in field, as opposed to sediment cores in the laboratory, will be considered. It is obviously more convenient to conduct the measurements in the laboratory, and the measurements will be made as soon as the sediment core is received (approximately one hour).

Page 2-7 to 2-13) "Additional review of the previous data might help..."

The comments on the complexity of the sediment chemistry and toxicity, and particularly the grain size effects, are appreciated. The sampling locations for most BERC studies have been specifically selected at the outfalls where the highest chemical concentrations have been detected in the past PRC studies. The studies of toxicity and associated TIE, as well as the pore water and sediment chemistry, will be useful in developing some rudimentary understanding of these effects, and which may then be the basis for additional studies if the information is critical to the selected remedial options.

Page 3-9 Bioirrigation "Bioirrigation may enhance the movement of pore water contaminants back into the lagoon....."

Microelectrode measurements and analyses of squeezed pore water will provide data for redox profiles in the upper ten centimeters. If these profiles are not explainable by simple fickian diffusion, then we look into bioirrigation and tidally induced fluxes.

Pg. 4-2) "As mentioned above, PRC is collecting a large number of cores ... a much better idea of contaminant levels."

It is uncertain whether the PRC data will be available before the BERC sampling begins. As stated above, the BERC sampling locations have been selected at the outfall discharge points, and where the highest level of chemicals have been detected in past PRC studies.

Pg. 5-11) The TIE procedures will be conducted on pore water ...in-situ chemistries. ..."

Pore water for toxicity testing and TIE will be extracted by centrifugation of near surface sediments, whereas the complete pore water composition will be collected from the squeezer apparatus with an expected depth discretion of 3-5 cm; the microelectrode measurements should give a depth discretion of a few millimeters. The depth of the sediment core from which the pore water is extracted/analyzed and the analyses that are performed are a function of the amount of water required to perform the available analysis method.

Pg. 5-19) "Will bioavailability evaluation include metals?"

Metal analyses are not planned because of funding limitations.

Response to Comments Contained in Memorandum of 22 October 1996 to Ken Spielman from Code 09KRE

General Comment

For the SHSP to be user friendly it is recommended that rather than referencing the applicable Section ... BERC Program Health and Safety Plan ...

This SHSP has been developed to be concise yet reasonably complete to address actual site conditions for field use. For completeness the first time reader is referred to the program document, and which will be present onsite along with the SHSP.

Specific Comments

1. Section 7 of Sampling and Analysis Plan SOPs. ... each SOP should address required PPE, and sample collecting procedures with a cross reference to the pertinent SHSP section.....

BERC believes the issue of PPE is sufficiently covered in the SHSP, and selection of the PPE is a function of the actual site specific monitoring results and site conditions. PPE is not necessarily part of an SOP unless some specific exposure is inherent in the performance of the SOP.

2. Site Specific Health and Safety Plan. Recommend adding a reference to the appointment of an alternate SHSO in the instances that Mr. Chiu's is absent from site.

The text has been revised to address this comments. BERC notes that Mr. Arvind Acharya is now the Project Manager for the proposed work, and will also serve as the SHSO. If he cannot be on site, Mr. Acharya shall designate an alternate SHSO who shall be approved beforehand by Dr. Hunt, the Principal Investigator. According the directions of the ROICC, the alternate SHSO will also be identified to the ROICC.

3. Section 2. Recommend adding a Field Personnel section that provides the anticipated number of field personnel and expected hours of work.

The initial field work will be of approximately three weeks duration, and will require the presence of the Project Manager in several roles (please see SHSP) and to oversee sampler subcontractors. The staffing for the field work is not expected to be complex, and the ROICC will be informed as to the persons to be in the field during any activity.

4. Section 3.2. For each identifiable work task by Site, complete Figure 1, Hazard Analysis Form found in Section 3.2 of the BERC Program HSP, and provide as an attachment to the SHSP.

This form has been included as Attachment 3-2 in the revised SHSP.

5. Section 3.2.2. Recommend the inclusion of drilling (soil boring) activities.

The drilling activities are actually soil coring to a maximum depth of one meter in the landfill wetlands and sediment coring from a barge in the lagoon. These activities are straightforward and are not expected to pose exceptional or unusual health and safety challenges, especially because the concentrations of chemicals in soils and sediments have been found to be low in previous investigations.

6. Section 3.2.2.3. Recommend changing the section title to Heat and Cold Stress as section discusses both.

The text has been revised to read "Heat and Cold Stress".

7. Section 4. Recommend rephrasing Sentence 1 to reflect the need for 40 hours for some field personnel.

The bulk of the studies will involve the handling of wet sediments, soil coring to depths of less than one meter, and soil gas and ground water sampling using push-type samplers. High concentrations of chemicals have not been measured in the sediments and soils (please see Table 3-1 of the SHSP). The 24 hour training is then believed to be sufficient for the proposed effort, although some of the field personnel do have the 40-hour course. Additionally, the reference to the use of a PEL is appropriate for a correct exposure time scenario.

8. Section 6 Para. 1, Sentence 4. Recommend adding that the visitors to EZ must meet the same medical and training requirements as project field personnel.
The text has been amended to state the following. "Authorization shall be granted only if visitors meet the same medical and training requirements as project field personnel. Either the ATG PM or SHSO will also log all employees and visitors who enter the EZ."

9. Section 7, Attachment 7-4. Recommend that required PPE be broken down by work operation rather than by zone. Respiratory protection is not addressed.
The following text has been added to Section 7. "As described in Section 3.2, site work is not anticipated to more than EPA level D PPE. However, as discussed in Section 9, air monitoring will be used to confirm that respiratory protection is not necessary. Respiratory protection shall be selected based on air monitoring results and shall be reviewed and approved by Mr. Michael Connor, CIH."

10. Section 9.1. Initial air monitoring to determine personnel exposures and the required EPA PPE level is not addressed. Downgrading of respiratory protection is addressed in this section but not in the SHSP, Section 7.
Section 7 has been modified to address the topic of air monitoring.

11. Section 10. Location of emergency supplies and equipment is not identified. The availability of drinking water and toilet facilities is not addressed.
The text has been modified to indicate that a first aid kit will be kept onsite. Additionally, Section 12.0, Sanitation, has been added. An adequate supply of potable drinking water shall be available at work sites outside designated exclusion zones..

The location of the nearest toilets shall be identified at the beginning of each days field activities. Ample time shall be allowed to access these facilities as needed.

12. Section 10.5. Add that a copy of the completed Accident/Incident form will be provided to Navy Contact (ROICC) within the prescribed timetable.
The text has been revised to state that a copy of the completed Accident/Injury form shall be submitted to the Resident Officer in Charge of Construction within the prescribed timetable.

13. Appendix B, Acoustic Imaging Safety Plan dated 28 June 1996, Section 4.1, Para. 2, Sentence 4, Page 6. Recommend removal of sentence as not being applicable or correct reference. 19 CFR 1926.106 addresses Working Over or Near Water and not Live Electrical Work.
The acoustic imaging task has been completed without incident, but this correction in the reference is noted.

Response to Comments Contained in Memorandum October 7, 1996 to Ken Spielman from Gilbert Nickelson.

General Comments

No responses are necessary

Specific Comments

a. Page 4, Section 3.2. Hazard Analysis. Recommended to change sentence number 3, paragraph number 5, "...contaminants are sorbed to..." to read ...contaminants are absorbed in the soil..., or use absorption.

The term sorption is appropriately used in the environmental science community when the mechanism of adsorption or absorption is unclear. The hazard analysis form from the program plan has been completed and included as Attachment 3-2.

b. Page 6, Section 3.2.2.3. ...standard safety procedures for heat stress-related hazards is contained in Section 12.15....All site personnel should be familiar with the symptoms of heat or cold...

The text has been amended to include more information on cold stress.

c. Page 6, Section 4. Work in the exclusion zones of the project.....Assumptions concerning worker exposure above the PEL/TLV should not be made....

The point regarding the 40-hour work week and the use of PEL is correct, and selection of respiratory protection will be based on the correct interpretation of the PEL. BEREC believes that the 24-hour training is sufficient for the planned work because of the infrequent presence of most workers at the sites and because of the relatively low chemical concentrations of soil and sediment. The text has been changed to include the 40 hr training requirement and when the 24 hr training is appropriate.

d. Page 4, Sub-Section 3.2.1 "Chemical Hazards" "Exposure Monitoring" a) Information is not provided indicating the location or the frequency of air-monitoring that will be performed at this site. b) Information pertaining to calibration and maintenance of direct reading air-monitoring equipment is not provided. c) A method to inform employees of monitoring results is not provided.

The stated air monitoring program is believed to be appropriate because VOCs have not been identified at the sites, and because the SVOCs and metals are at low concentrations and associated with generally wet sediments or soils from the wetlands areas. Air monitoring will be continuous and in the immediate area of the work activity. As necessary, the SHSO will notify project personnel of any air monitoring results that are above the ambient background levels.

e. Page 7, Section 6, addresses "Site Control Measures" ...Control methods and training requirements in accordance with references...

Site controls are addressed in the program document, and the text in Section 6 has been modified to be more explicit regarding logging of persons at the sites.

f. Page 9, Section 8, addresses "Decontamination" In sub-section 8.1 there is no mention of a shower for workers as a part of good personal hygiene.

Decontamination procedures shall be discussed during site specific training and reviewed during tailgate safety meetings. However, appropriate PPE should sufficiently protect workers during sampling of sediment and soils, and onsite showering facilities are not necessary.

g. Page 11, Section 10, "*Emergency Response*" a) Information regarding who is to provide emergency first aid/CPR support on-site is not provided.

b) Information concerning emergency decontamination is not provided.

c) Information regarding the availability of emergency response equipment, i.e., emergency eyewash equipment, first aid kits, or supplemental personal protective equipment (PPE) is not provided. d) "*All personnel not trained in spill control cleanup shall evacuate the area.*" The additional training requirements for the spill responders in not provided.

a) The text has been revised to state that only 40-hour trained personnel may be used to respond to emergencies. The Base Fire Department shall be called for large fires or for responses to spills or releases in excess of 50 pounds or 50 gallons; BERC notes that no large volumes of liquid or solids are part of field activities other than site soils or water from the lagoon or wetland ponds.

b) As stated in Section 8.3, emergency decontamination procedures shall consist of the removal of contaminated clothing before either treatment or transportation of the victim(s). Procedures are also discussed in the Program plan.

c) There will be two first aid/CPR trained person on site during field activities. These persons shall also be trained on bloodborne pathogens as required by Section of the BERC Health and Safety Plan (Program). These individuals shall be identified during routine tailgate safety meetings. A first aid kit shall be kept available on site.

d) Base personnel will be called to handle any spill events; however, the nature of the investigations to be conducted do not use any large volumes of liquids except pond or lagoon water.